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[1]

AN ANALYSIS
OF THE
INDUSTRIAL
INSTRUMENTATION
TRADE

Government
Publications

PREPARED BY
A NATIONAL COMMITTEE
APPOINTED BY
THE DEPARTMENT OF LABOUR
OTTAWA, CANADA

1965

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AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

GENERAL TABLE OF CONTENTS

INTRODUCTION:

History and Organization
Nature and Scope of the Analysis
Procedure
Purpose and Use of the Analysis

DIVISIONS OF THE ANALYSIS:

GENERAL PROCEDURES

BLOCK 1:	Trade Tools	Page 1
2:	Measuring Devices and Techniques	9
3:	Layout	21
4:	Fabrication	30
5:	Installation and Services	42
6:	Test Equipment and Standards	63

MEASUREMENT

7:	Temperature	75
8:	Pressure	104
9:	Level and Density	129
10:	Flow	171
11:	Viscosity and Consistency	220
12:	Weight - Force - Load	234
13:	Time - Motion - Vibration	250
14:	Dimensional	264
15:	Counters	274
16:	Analytical Instruments	285
17:	Direct Acting Indicating and Recording Instruments	397
18:	Indirect Acting (Servo-Operated) Indicating and Recording Instrument Devices	410
19:	Pneumatic Signal Transmission Systems	432
20:	Electrical Signal Transmission and Telemetering	444
21:	General Alarm and Signal Devices	457
22:	Data Processing	465

CONTROL

23:	Self-Operated Controllers	481
24:	Hydraulic Controllers	490
25:	Pneumatic Controllers	493
26:	Electric Controllers	509
27:	Control Systems	519
28:	Final Control Elements	529

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- CARPENTRY •
- COOKING (COMMERCIAL) •
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AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. INTRODUCTION .

HISTORY AND ORGANIZATION

The first National Conference on Apprenticeship in Trades and Industries held in Ottawa in May 1952, recommended that the Federal Government be requested to co-operate with Provincial Apprenticeship Committees and those concerned with Apprenticeship Training in preparing trade analyses of a number of skilled occupations.

In 1962, the Technical and Vocational Training Branch, Department of Labour, Ottawa, decided to undertake an analysis of the Industrial Instrumentation Trade through a committee of four experts nominated from a board cross-section of industry throughout Canada. These were: Mr. W. G. Small, P.Eng., Consolidated Mining and Smelting Company of Canada Limited; Mr. D. A. King, P.Eng., Crown Zellerbach (Canada) Limited; Mr. B. Sawicki, P.Eng., Canadian Industries Limited; and Mr. J. Deas, (Instrument Foreman), Canadian Chemical Company Limited. This committee was convened by Mr. Gordon L. Bratt, Training Consultant (Curricula), Department of Labour, Ottawa, Ontario.

NATURE AND SCOPE OF THE ANALYSIS

The scope of this analysis, as indicated by the title, is limited to the Industrial Instrumentation Trade, and includes only those techniques required for calibration, installation, maintenance and repair of measuring and control instruments used in the process industries. It does not, for instance, cover such specialized fields as aeronautical, scientific or medical instrumentation.

Instrumentation is an interdisciplinary science that uses almost every known physical and chemical phenomenon to measure and control process variables. The tradesman is confronted with a bewildering array of complex mechanical and electrical devices, and must depend to a large extent on detailed instruction manuals. A sound fundamental knowledge of scientific principles and their applications is essential to enable him to interpret these instructions intelligently, and to keep abreast of new developments.

The instrument tradesman must also have a thorough knowledge of the various processes with which he may become involved. Instruments are operating tools, used for controlling a process, and the man responsible for their care and maintenance is part of the operating team. He cannot do his job properly without understanding the process. A detailed knowledge of a process can only be obtained on the job, but a solid foundation of mathematics, physics and chemistry is an essential prerequisite.

It is axiomatic that a safe workman is a good workman, and nowhere is this more true than in the instrumentation trade. An instrument man is not only responsible for his own safety but also for the safety of others, and must perform his work in a careful and conscientious manner. The hazards involved are mostly peculiar to the specific plant and process concerned, and cannot be brought out in an analysis such as this. Safe work methods should be emphasized in any course of study and reference made to possible hazards conditions that might result from careless or incompetent work. A knowledge of first aid procedures is desirable, and it is recommended that an instrument tradesman hold a valid St. John's Ambulance Society First Aid Certificate.

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. INTRODUCTION .

NATURE AND SCOPE OF THE ANALYSIS

It is essential, if instrument maintenance work is to be done efficiently, that detailed data and history records be kept. It may not be the function of an instrument mechanic to do the clerical work involved, but in most cases the information to be recorded will originate with him. He should be able to write clear, concise reports of work he has done, and have an appreciation of the importance of record keeping and a knowledge of methods used. His general knowledge should also include recognized instrument identification codes and symbols.

Instrument work is usually a team effort, involving close co-operation with other tradesmen, such as electricians and pipefitters, and with plant operating personnel. The ability to obtain the goodwill and co-operation of others is a highly desirable attribute of an instrument man. Other desirable attributes not specifically set down in this analysis include: cleanliness, orderliness, resourcefulness, ingenuity, a well developed sense of responsibility, and an intolerance of anything but the highest standards of workmanship.

PROCEDURE

Each committee member elected to prepare certain sections of the overall task and as the work proceeded, submitted proof copies to the others so that the benefit of all opinions was available throughout. It was hoped that this procedure would ensure the validity of the completed project.

Furthermore, to ensure that the final result would be acceptable throughout Canada, draft copies were distributed widely to Industry and Provincial Vocational Education Authorities for critical comment. Suggestions emanating from these sources were reviewed and any valid changes incorporated into the text.

PURPOSE AND USE OF THE ANALYSIS

It should be emphasized that this is not a course of study, and is not intended that operations be mastered in the sequence shown. The analysis is recommended as the basis of instruction in industry and in trade schools and institutes, as a guide to foremen for on-the-job training and as a basis for evaluating previous experience.

Officials of the Federal Department of Labour desire to express their sincere appreciation of the many company officials who attended the meetings of the National Committee and contributed to the preparation of this analysis and for the co-operation, interest and help of the provincial Directors of Apprenticeship and Vocational Education.

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. GENERAL PROCEDURES .

BLOCK 1: Trade Tools

TABLE OF CONTENTS

UNIT 1: Hand Operated	Page 2
2: Power Operated	5

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. GENERAL PROCEDURES .

BLOCK 1: Trade Tools

UNIT 1: Hand Operated

OPERATIONS	KNOWLEDGE
<hr/>	
1. Cutting material with metal saws	(a) Type, care and use of metal cutting saws (b) Size of blades (c) Number of teeth to suit job (d) Optimum speed of cutting (e) Type and use of machinists vises and clamps (f) Necessity of protecting finished parts when clamping
2. Cutting and reaming pipe or tubing	(a) Methods of holding pipes (b) Type and use of pipe vises (c) Type and use of pipe cutters (d) Type and use of metal tubing cutters (e) Procedures for flaring metal tubing (f) Importance of square cuts (g) Purpose and importance of reaming tubing before flaring (h) Care of tools
3. Cutting a thread, internal or external	(a) Type and size of taps (b) Use and care of taps (c) Type and size of dies (d) Use and care of stocks and dies (e) Type and use of lubricants
4. Assembling pipe and tube fittings	(a) Type, size and materials of pipe and tube fittings (b) Type, size, care and use of pipe wrenches (c) Care, use and sizes of: (i) open-end spanners (ii) multi-point spanners (iii) ratchet and socket sets

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. GENERAL PROCEDURES .

BLOCK 1: Trade Tools

UNIT 1: Hand Operated

OPERATIONS

KNOWLEDGE

- | | |
|--|--|
| 5. Welding, cutting, brazing and soldering | (a) Type, care and use of torches
(b) Type and care of gases used
(c) Selection of tips
(d) Techniques in various operations
(e) Fluxes and their use
(f) Type and use of filler rod
(g) Safe procedures when handling gas cylinder
(h) Type of goggles and protective shields
(i) Type and use of solder
(j) Type, size and use of soldering irons |
| 6. Removing a broken stud or bolt | (a) Type and use of extractors
(b) Improvised methods |
| 7. Removing a pin or key | (a) Type and size of drifts and punches
(b) Use of punches
(c) Care of punches |
| 8. Installing screws in wood or metal | (a) Type and size of wood and metal screws
(b) Use of standard, Robertson and Phillips screwdrivers
(c) Importance in the use of the correct size of screwdriver
(d) Methods of sharpening and tempering standard screwdrivers |
| 9. Placing nuts, bolts and washers | (a) Type, size and threads of nuts and bolts
(b) Washers - plain and lock; purpose and types
(c) Type, care and use of wrenches including torque wrenches
(d) Size of wrenches |
| 10. Cutting holes in wood, metal concrete or masonry | (a) Size and type of hammers and their use
(b) Size and type of chisels
(c) Methods of sharpening of chisels
(d) Results of using mushroom headed tools
(e) Star drills and their uses
(f) Special drills and their uses
(g) Techniques of breaking through |

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. GENERAL PROCEDURES .

BLOCK 1: Trade Tools

UNIT 1: Hand Operated

OPERATIONS	KNOWLEDGE
11. Drilling holes in wood or metal by hand	(a) Use and care of hand drills and braces (b) Type and size of twist drills (c) Type and size of spur bits including expansion bits (d) Method of sharpening drills (e) Method of drilling light gauge sheet metal (f) Techniques of breaking through
12. Sawing lumber as required	(a) Type of hand saws and their use
13. Cutting and stripping wire	(a) Common types of pliers, cutters and their uses (b) Methods of stripping insulation off wire
14. Filing	(a) Type, size and use of files (b) Methods of filing e.g. posture, positioning work in vise, strokes per minute (c) Procedures for filing curved or plane surfaces (d) Methods of cleaning files (e) Effects of soft and hard materials
15. Lifting heavy objects	(a) Type, care and use of rope hoists (b) Type, care and use of crane hoists (c) Type, care and use of jacks (d) Methods of hanging hoists (e) Use and care of slings (f) Proper techniques when lifting heavy objects (g) Type and use of special lifting tackle e.g. "Lug-All" (h) Importance of safe procedures
16. Painting equipment	(a) Preparation of the surface for painting (b) Knowledge of paints and paint thinners used in the trade (c) Care and use of paint brushes (d) Techniques of painting pipes, etc. without splattering building (e) Type, use and application of plastic coatings

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. GENERAL PROCEDURES .

BLOCK 1: Trade Tools

UNIT 2: Power Operated

OPERATIONS

KNOWLEDGE

1. Drilling holes in wood of metal

- (a) Type, size and use of electric and pneumatic portable drills
- (b) Type, size, use and component parts of drills presses
- (c) Type, size and use of drills:
 - (i) twist
 - (ii) straight fluted
 - (iii) flat
- (d) Procedures for holding work while drilling
- (e) Purpose and use of alignment guides on portable drills
- (f) Methods of drilling thick or thin metal
- (g) Procedures for laying out holes
- (h) Importance of correct speed and drill material
- (i) Type and use of lubricants
- (j) Techniques of breaking through
- (k) Hazards in the use of improper electrical connections
- (l) Methods of sharpening drills
- (m) Importance of goggles and protective shields
- (n) Mathematics:
 - (i) linear measurement for layout
 - (ii) properties of circles and angles
- (o) Science:
 - (i) properties of carbon and high speed steel
 - (ii) speed ratio mechanisms

2. Drilling holes in concrete

- (a) Type, size and use of masonry drills
- (b) Methods of using electric or pneumatic hammers
- (c) Methods of sharpening masonry drills
- (d) Purpose and use of personal protective equipment

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. GENERAL PROCEDURES .

BLOCK 1: Trade Tools

UNIT 2: Power Operated

OPERATIONS	KNOWLEDGE
<hr/>	
3. Cutting and threading pipe by machine	<ul style="list-style-type: none">(a) Methods of using pipe threading machine(b) Type, size and use of stocks, dies and cutters(c) Use and care of end reamer attachments(d) Type and use of lubricants(e) Methods of correcting threat fit(f) Importance of clean equipment(g) Importance of eye protection
4. Shooting studs	<ul style="list-style-type: none">(a) Type, purpose and use of stud guns(b) Type, size and use of charges and fasteners(c) Importance of correct size of fastener for different materials and loads(d) Hazards of improper use of guns and explosive charges
5. Grinding	<ul style="list-style-type: none">(a) Type, care and use of stationary and portable grinders(b) Type and use of grinding wheels(c) Importance of correct grinding technique(d) Methods of holding work(e) Hazards of overspeeding grinding wheels(f) Hazards of improper application of pressure to grinding wheels(g) Methods of dressing wheels(h) Importance of controlling material temperature(i) Type and use of portable disc sanders(j) Importance of proper use and care of electrical cords and connections(k) Conditions contributing to electrical shock(l) Science:<ul style="list-style-type: none">(i) heat treatment of metals(ii) physical properties of ferrous metals

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. GENERAL PROCEDURES .

BLOCK 1: Trade Tools

UNIT 2: Power Operated

OPERATIONS

KNOWLEDGE

6. Operating lathes

- (a) Type, purpose and function of lathes
- (b) Type, material and use of lathe tools
- (c) Methods of adjusting tool position
- (d) Importance of tool position in producing a smooth finish
- (e) Methods of grinding tools to produce the proper rake angle
- (f) Type and use of components for setting up work in lathe
- (g) Methods of preparing stock for lathe work:
 - (i) squaring stock
 - (ii) locating the centre of stock
 - (iii) mounting work on centres
- (h) Procedures for facing and turning
- (i) Methods of drilling and boring
- (j) Use of compound slide rest
- (k) Procedures for aligning lathe centres
- (l) Use of calipers and micrometers
- (m) Methods of speed adjustment
- (n) Importance of goggles and protective shields
- (o) Mathematics:
 - (i) properties of triangle and circle
 - (ii) linear measurement to calculate size
 - (iii) geometric constructions to find centres of stock
 - (iv) ratio and proportion to determine speed ratios
- (p) Science:
 - (i) physical properties of ferrous and non-ferrous metals
 - (ii) speed ratios of pulleys worm and spur gearing
 - (iii) precision and non precision measuring devices
 - (iv) fits and clearances

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. GENERAL PROCEDURES .

BLOCK 1: Trade Tools

UNIT 2: Power Operated

OPERATIONS	KNOWLEDGE
<hr/>	
7. Using power operated wrenches	(a) Type and size of pneumatic and electric operators (b) Importance of correct power connections (c) Type, size and use of socket and socket extension attachments (d) Importance of proper alignment and correct attachment to fastener
8. Using a pantograph	(a) Type, purpose and use of a pantograph (b) Methods of adjusting for size (c) Procedures for setting cutting speed (d) Type, purpose and use of cutters (e) Methods of adjusting cutter height (f) Methods of making nameplates, dials, etc. (g) Procedures for cutting different materials (h) Mathematics: (i) linear measurement to calculate size (ii) ratio and proportion to determine pantograph adjustment (i) Science: (i) linkages (ii) levers

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. GENERAL PROCEDURES .

BLOCK 2: Measuring Devices and Techniques

TABLE OF CONTENTS

UNIT 1: External and Internal Measurement	Page 10
2: Angular and Contour Measurement	15
3: Comparative Measurement	17
4: Surface Measurement	20

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. GENERAL PROCEDURES .

BLOCK 2: Measuring Devices and
Techniques

UNIT 1: External and Internal Measurement

OPERATIONS	KNOWLEDGE
<hr/>	
1. Measuring with a rule	<ul style="list-style-type: none">(a) Interpretation of drawings to determine:<ul style="list-style-type: none">(i) size dimensions(ii) location dimensions(b) Types and features of rules:<ul style="list-style-type: none">(i) flexible(ii) tape(iii) hook(iv) shrink(c) Types of rule calibrations:<ul style="list-style-type: none">(i) common fraction system(ii) decimal system(iii) metric system(d) Theory of dimensions(e) Methods of obtaining accurate measurement with a rule(f) Application of accessories used with rules(g) Procedures used to measure:<ul style="list-style-type: none">(i) keyways(ii) shoulders, etc.(h) Accuracies obtainable(i) Care and storage of rules and attachment(j) Use of machinist's handbooks and C.S.A. Standards(k) Mathematics:<ul style="list-style-type: none">(i) linear measure to calculate dimensions(ii) conversion to fractional decimal and metric systems(l) Science: fits and clearances

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. GENERAL PROCEDURES .

BLOCK 2: Measuring Devices and Techniques

UNIT 1: External and Internal Measurement

OPERATIONS	KNOWLEDGE
<hr/>	
2. Measuring with a straight edge and a solid square	<ul style="list-style-type: none">(a) Type and application of straight edges and squares(b) Methods of testing flat surfaces with a straight edge(c) Use of light and magnifying glasses when checking a surface(d) Causes of deflection(e) Holding devices for inspection of angles, surfaces, etc.(f) Methods of inspecting work using a square, surface plate and feelers(g) Methods of testing square for accuracy(h) Need for cleanliness of work and measuring devices(i) Care and storage of squares and straight edges(j) Science: Reflection, refraction and transmission of light
3. Testing and inspecting with surface and angle plates	<ul style="list-style-type: none">(a) Type and use of surface and angle plates(b) Type and use of surface and angle plate accessories(c) Methods of cleaning surface plates(d) Methods of testing surface and angle plates for accuracy(e) Use of mechanics blue for testing flatness(f) Methods of securing work to surface plates(g) Mathematics:<ul style="list-style-type: none">(i) calculations to determine angular measurement

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. GENERAL PROCEDURES .

BLOCK 2: Measuring Devices and Techniques

UNIT 1: External and Internal Measurement

OPERATIONS	KNOWLEDGE
<hr/>	
4. Measuring with calipers	<ul style="list-style-type: none">(a) Type and feature of inside and outside calipers(b) Selection of calipers for type of job(c) Method of adjusting a caliper for accurate dimensions(d) Method of obtaining correct feel(e) Method of setting a caliper to a rule(f) Procedures used to measure inside and outside diameters and lengths(g) Methods of transferring dimensions to a micrometer, vernier and calipers(h) Application of transfer calipers(i) Calculation required to transfer dimensions(j) Accuracy obtainable(k) Care and storage of calipers
5. Measuring with a micrometer	<ul style="list-style-type: none">(a) Type and feature of outside and inside micrometers(b) Names of the micrometer parts(c) Method of reading a micrometer in thousandths and tenths(d) Importance of "feel" technique for accurate measurement(e) Methods of holding a micrometer(g) Importance of avoiding tipping or canting while measuring(h) Effect of temperature on measurements(i) Methods of transferring dimensions(j) Methods of checking and adjusting micrometers(k) Methods of measuring three fluted reamers(l) Care and storage of micrometers(m) Mathematics: conversion of decimal to fractional and metric values

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. GENERAL PROCEDURES .

BLOCK 2: Measuring Devices and Techniques

UNIT 1: External and Internal Measurement

OPERATIONS	KNOWLEDGE
<hr/>	
6. Measuring with vernier-calipers, depth gauges, and protractors	<ul style="list-style-type: none">(a) Type, feature, and use of vernier calipers and depth gauges(b) Interpretation of vernier scales(c) Type of work that can be measured with vernier calipers(d) Procedure for adjusting verniers to obtain correct "feel"(e) Use of magnifying glass when reading verniers(f) Procedures for using indicators, micrometers, and verniers for measuring depth(g) Methods of setting a vernier height gauge to accurate dimensions(h) Type and feature of vernier bevel protractors(i) Testing an angle using a vernier protractor(j) Methods of testing the accuracy of vernier tools(k) Various types of vernier measuring attachments(l) Care and storage of verniers(m) Science: precision and non-precision measuring devices
7. Measuring small diameter holes	<ul style="list-style-type: none">(a) Type and use of small hole, and telescopic gauges(b) Techniques in obtaining small hole measurements(c) Method of obtaining correct "feel" with small hole and telescopic gauges(d) Methods of transferring a size to micrometer, verniers, etc.(e) Calipering with telescopic or ball-type gauges(f) Type and use of plug gauges(g) Standards for plug gauges(h) Care and storage of small hole measuring tools(i) Science: fits and clearances

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. GENERAL PROCEDURES .

BLOCK 2: Measuring Devices and
Techniques

UNIT 1: External and Internal Measurement

OPERATIONS

KNOWLEDGE

8. Measuring slots and grooves

- (a) Type and feature of gauge blocks, feelers, comparators, and indicators
- (b) Methods of using feelers and gauge blocks to obtain dimensions
- (c) Accuracy obtainable with feeler gauges
- (d) Method of wringing gauge blocks together
- (e) Techniques used in testing slots, grooves, and dovetails
- (f) Methods of testing grooves using discs, rods, verniers, and micrometers
- (g) Testing grooves and slots for central position with gauge blocks, surface plate, V blocks, and indicators
- (h) Care and storage of measuring instruments
- (i) Mathematics: fractional and decimal values to calculate gauge block build-up

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. GENERAL PROCEDURES .

BLOCK 2: Measuring Devices

UNIT 2: Angular and Contour Measurements

OPERATIONS	KNOWLEDGE
<hr/>	
1. Measuring angular surfaces	<ul style="list-style-type: none">(a) Interpretation of drawings to determine:<ul style="list-style-type: none">(i) reference points(ii) accuracy(b) Type and feature of templates, protractors and indicators(c) Type and use of a combination sets(d) Methods of reading and adjusting vernier protractor(e) Technique used for testing angles with protractors(f) Procedures used to inspect angular surfaces with a sine bar, indicator, discs, plugs and micrometers(g) Methods of making templates(h) Methods of testing tapers with a plug gauge(i) Accuracy obtainable with various measuring tools(j) Care and storage of precision instruments(k) Mathematics:<ul style="list-style-type: none">(i) fractional and decimal values to calculate gauge block build-ups(ii) calculation of angular and roll dimensions(l) Science:<ul style="list-style-type: none">(i) precision and non-precision measuring devices

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. GENERAL PROCEDURES .

BLOCK 2: Measuring Devices

UNIT 2: Angular and Contour Measurements

OPERATIONS	KNOWLEDGE
<hr/>	
2. Measuring and inspecting contours and radii	<ul style="list-style-type: none">(a) Type and feature of special templates and gauges for testing contours(b) Type and use of radius gauges(c) Methods of holding work for checking contours and radii(d) Use of paper as a "feeler" with templates(e) Gear tooth terminology(f) Techniques used to test gear tooth parts using; gear tooth vernier, pins, micrometers, and comparators(g) Method of testing profiles and cavities(h) Accuracy obtainable(i) Care and storage of inspection tools(j) Mathematics:<ul style="list-style-type: none">(i) geometrical calculations for angular and contour measurements(ii) calculations to determine centers of radii and co-ordinate points(iii) gear calculations(k) Science:<ul style="list-style-type: none">(i) gear tooth form and characteristics<ul style="list-style-type: none">(a) involute(b) cycloidal(ii) gear trains

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. GENERAL PROCEDURES .

BLOCK 2: Measuring Devices

UNIT 3: Comparative Measurement

OPERATIONS	KNOWLEDGE
<hr/>	
1. Inspecting with dial indicators	<ul style="list-style-type: none">(a) Type and feature of dial indicators(b) Nomenclature and use of dial indicators(c) Selection of the indicator(d) Type of work that can be inspected with indicators(e) Method of checking work for parallelism(f) Procedures used to indicate tapers(g) Methods of testing work for roundness and size(h) Work holding devices(i) Methods of reading indicators for limits and tolerances(j) Factors limiting indicators range(k) Type and use of indicator attachments(l) Methods of checking an indicator for accuracy(m) Accuracy of dial indicators(n) Science:<ul style="list-style-type: none">(i) precision and non-precision(ii) measuring devices(iii) fits and clearances

. GENERAL PROCEDURES .

BLOCK 2: Measuring Devices

UNIT 3: Comparative Measurement

OPERATIONS	KNOWLEDGE
2. Measuring and testing with blocks	<ul style="list-style-type: none"> (a) Type and feature of gauge block sets (b) Gauge block manufacture (c) Accuracy of gauge block sets (d) Care and cleanliness of gauge blocks and accessories (e) Application of gauge block accessories (f) Use of wear blocks (g) Methods of selecting gauges (h) Methods of wringing blocks together (i) Effect of temperature on gauge block size (j) Methods of testing and scribing accurate lines (k) Methods of checking accuracy of micro-meters with gauge blocks verniers (l) Methods of setting a comparator to gauge blocks (m) Care and storage of gauge blocks (n) Mathematics: <ul style="list-style-type: none"> (i) trigonometry to calculate angular dimensions (ii) calculation of angular measurement and values (o) Science: <ul style="list-style-type: none"> (i) thermal expansion and contraction (ii) elementary scientific measurement

. GENERAL PROCEDURES .

BLOCK 2: Measuring Devices

UNIT 3: Comparative Measurement

OPERATIONS	KNOWLEDGE
3. Measuring and inspecting with fixed gauges	<ul style="list-style-type: none"> (a) Interpretation of drawings to determine work tolerances (b) Type and feature of gauges: <ul style="list-style-type: none"> (i) snap (ii) plug (iii) ring (iv) taper (v) thread (vi) limit (c) Care and cleanliness required for gauging purposes (d) Gauge standards, design limits, tolerances, etc. (e) Type of standard plug, ring and snap gauges (f) Limitations of gauges (g) Techniques for using gauges when inspecting work (h) Procedures used for gauging internal and external dimensions (i) Accuracy of fixed gauges (j) Care and storage of gauges (k) Science: <ul style="list-style-type: none"> (i) gauge design (ii) fits and clearances

. GENERAL PROCEDURES .

BLOCK 2: Measuring Devices

UNIT 4: Surface Measurement

OPERATIONS	KNOWLEDGE
1. Measuring and inspecting surface finishes	<ul style="list-style-type: none"> (a) Interpretation of drawings to determine finish required (b) Type and feature of surface measuring equipment (c) Features of surface finishes (d) Surface quality symbols (e) Nomenclature of machine, ground and lapped surfaces (f) Standards of surface finishes (g) Type and use of charts, tables, handbooks and C.S.A. Standards (h) Comparison method of testing machine surfaces (i) Purpose of micro-finishes (j) Inspection machines used to test surfaces for micro-finishes (k) Methods of identifying surface lay, waviness and flaws (l) Techniques used in testing a surface (m) Methods of setting a surface indicator to test micro-finishes (n) Care and use of special attachments for a surface indicator (o) Measuring internal and external surfaces (p) Care and storage of testing equipment (q) Science: <ul style="list-style-type: none"> (i) surface quality

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. GENERAL PROCEDURES .

BLOCK 3: Layout

TABLE OF CONTENTS

UNIT 1: Layout Techniques	Page 22
2: Location	25
3: Form	28

. GENERAL PROCEDURES .

BLOCK 3: Layout

UNIT 1: Layout Techniques

OPERATIONS	KNOWLEDGE
1. Preparing equipment and work for layout	<ul style="list-style-type: none"> (a) Interpretation of drawings to determine layout characteristics (b) Factors governing the selection of layout plates and tables, e.g.: <ul style="list-style-type: none"> (i) size and shape of work (ii) type of layout (iii) accuracy required (c) Type, use and feature of layout plates and tables (d) Care, inspection, and testing of layout plates and tables (e) Type, use and feature of layout accessories, e.g.: <ul style="list-style-type: none"> (i) gauge blocks (ii) rods and centres (iii) indicators (iv) parallels (f) Methods of securing work to bench (g) Methods of cleaning, degreasing, and preparing work such as: <ul style="list-style-type: none"> (i) machined surfaces (ii) castings (iii) non-ferrous materials (iv) non-metallic materials (h) Type, use, feature and characteristics of layout coatings such as; dyes, chalk, fluids, etc. (i) Methods of applying layout coatings (j) Durability of layout coatings (k) Methods of removing layout coatings (l) Effects of layout fluids on non-metallic surfaces, such as plastics (m) Hazards in using surface cleaning fluids and acids (n) Hazards in using layout fluids (o) Care and storage of equipment (p) Science: <ul style="list-style-type: none"> (i) acids, bases and salts (ii) care and use of acids (iii) organic and inorganic solvents (iv) colour pigments (v) plastics (vi) properties of mixtures (vii) electrolysis

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. GENERAL PROCEDURES .

BLOCK 3: Layout

UNIT 1: Layout Techniques

OPERATIONS	KNOWLEDGE
2. Laying out straight lines	<ul style="list-style-type: none">(a) Interpretation of drawings and specifications(b) Factors governing types of layout work, procedures and layout tools(c) Reasons for working from reference or datum points(d) Use and application of surface gauges, vernier height gauges, and templates(e) Features and applications of a combination square set(f) Methods of setting layout tools to measuring tools and instruments(g) Methods of drawing a line parallel to a flat surface or straight edge(h) Procedures for scribing vertical lines(i) Use of angle plates for holding work(j) Layout procedures(k) Need for sharp layout tools(l) Use and application of witness marks(m) Maintenance of layout tools such as scribe, points, prick punches, squares, etc.(n) Care and storage of layout tools and equipment
3. Laying out lines at right angles	<ul style="list-style-type: none">(a) Type and application of layout tools such as squares, surface gauges, vernier height gauges, etc.(b) Methods of setting up work to an angle plate or fixture(c) Need for working from a reference point or two finished edges(d) Layout procedures(e) Geometrical method of checking lines using arcs, discs, and circles(f) Use of witness marks(g) Mathematics:<ul style="list-style-type: none">(i) calculation of distances from straight lines and datum lines(ii) geometrical constructions

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. GENERAL PROCEDURES .

BLOCK 3: Layout

UNIT 1: Layout Techniques

OPERATIONS	KNOWLEDGE
4. Laying out angular lines	<ul style="list-style-type: none">(a) Type and application of tools used for angular layout:<ul style="list-style-type: none">(i) vernier protractors(ii) sine bars(iii) gauge blocks(iv) angle plates(b) Use of templates and fixtures(c) Type and application of jig-plates, discs, and buttons(d) Procedures to layout accurate angles(e) Methods of checking angular layouts by indicating, projection and comparison(f) Mathematics:<ul style="list-style-type: none">(i) trigonometry to determine angle distances and arcs(ii) mathematical tables for checking, solving and inspecting angles
5. Laying out circles, radii, and subdividing	<ul style="list-style-type: none">(a) Methods of establishing centre points(b) Type and application of centre punches:<ul style="list-style-type: none">(i) hand(ii) transfer(c) Methods of locating the reference point(d) Type and application of core type, ball type, and false centres(e) Application of dividers, templates trammels, and discs for layout(f) Methods of setting dividers and trammels(g) Methods used to locate hole centres on a circle, radius, or an arc(h) Methods used to transfer layouts(i) Methods of subdividing(j) Use of various layout fixtures(k) Layout procedures(l) Mathematics:<ul style="list-style-type: none">(i) calculations relating to<ul style="list-style-type: none">(a) arcs(b) centre distances(c) circles(ii) calculation of angles and chords(iii) use of mathematical reference tables for division of circles and arcs

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. GENERAL PROCEDURES .

BLOCK 3: Layout

UNIT 2: Location

OPERATIONS

KNOWLEDGE

1. Laying out centres for holes
on round and irregular shapes

- (a) Interpretation of drawings and specifications to determine location
- (b) Type and application of holding devices for round and irregular work, such as, angle plates, magnetic tools, fixtures, centres, etc.
- (c) Type and feature of box squares, straight edges, etc.
- (d) Methods of locating and testing centres
- (e) Layout procedures for accurately spaced centres
- (f) Method of shifting centre locations
- (g) Need for a test circle and witness marks
- (h) Type and application of layout tools such as, height gauges, dividers and trammels
- (i) Methods of laying out using co-ordinates
- (j) Use and care of precision layout tools
- (k) Mathematics:
 - (i) geometric propositions used to layout centres on irregular work
 - (ii) co-ordinates

. GENERAL PROCEDURES .

BLOCK 3: Layout

UNIT 2: Location

OPERATIONS	KNOWLEDGE
2. Laying out for accurate hole drilling	<ul style="list-style-type: none"> (a) Interpretation of drawings and specifications to determine position (b) Type of holding devices for round and irregular work (c) Procedures to obtain centre points (d) Methods of adjusting a divider or vernier for dimensions (e) Methods of scribing proof circles (f) Purpose of witness marks on a proof circle (g) Methods of drawing a centre point when drilling to an accurate layout (h) Methods of testing centres on round shafts (i) Precision layout using buttons, discs, templates and rings (j) Use and application of sine bars, gauge blocks, buttons, discs, and fixtures (k) Care and storage of precision instruments (l) Mathematics: reference tables for laying out angles and circle spacing
3. Transferring layouts	<ul style="list-style-type: none"> (a) Methods of establishing a reference point or centre line (b) Type and application of special layout transfer tools such as, punches, transfer screws and automatic layout equipment (c) Type and feature of adjustable gauges (d) Use and application of templates (e) Procedures used in layouts of duplicate parts (f) Need for sharp lines and witness marks (g) Methods of inspecting layouts (h) Care and maintenance of layout equipment

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. GENERAL PROCEDURES .

BLOCK 3: Layout

UNIT 2: Location

OPERATIONS	KNOWLEDGE
<hr/>	
4. Laying out horizontal, vertical, and oblique centre lines in the field	(a) Interpretation of drawings to determine location and reference points (b) Type, care and use of rules, squares and protractors (c) Type, care and use of instrument levels (d) Type and use of liquid levels (e) Methods of using line levels (f) Use of chalk and chalk lines (g) Type and use of plumb bobs (h) Mathematics: (i) linear and angular measurement for layout

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. GENERAL PROCEDURES .

BLOCK 3: Layout

UNIT 3: Form

OPERATIONS	KNOWLEDGE
<hr/>	
1. Laying out to a template	<ul style="list-style-type: none">(a) Type and use of templates(b) Characteristics and application of templates(c) Methods of holding and fastening templates(d) Materials used for templates(e) Methods of making master templates(f) Use of comparators for checking template forms(g) Precision layout procedures(h) Application of base or locating lines(i) Requirements of precision angles and sharp lines(j) Care and storage of templates(k) Mathematics: geometrical construction for layout
2. Laying out contours	<ul style="list-style-type: none">(a) Methods of mounting and holding work re thin section, castings, etc.(b) Use of various layout tools, such as templates, trammels, discs, etc.(c) Geometrical calculations for contours and shapes(d) Use and purpose of reference points and base line(e) Layout procedures for arcs, circles and curved lines(f) Application of layout tools such as, vernier height gauges, gauge blocks, scribes and measuring devices(g) Methods of producing witness lines and marks(h) Allowances for machining(i) Methods of checking contours with master templates and comparators(j) Care and use of measuring and layout instruments(k) Mathematics:<ul style="list-style-type: none">(i) geometrical constructions(ii) geometrical propositions

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. GENERAL PROCEDURES .

BLOCK 3: Layout

UNIT 3: Form

OPERATIONS	KNOWLEDGE
<hr/>	
3. Laying out keyways, slots, and irregular shapes	<ul style="list-style-type: none">(a) Type, feature and dimension of keyways(b) Proportion of keys and keyways(c) Methods of laying out keyways using keyseat rules, V-blocks, etc.(d) Type and application of layout tools such as layout gauges and centre squares(e) Type and application of core, and bore false centres(f) Layout procedures for internal slots and keyways(g) Layout procedures for irregular shapes(h) Methods used to layout angular grooves(i) Use of reference tables for standard keyways, angular grooves, and special type keys(j) Care and storage of layout tools(k) Mathematics: calculations for<ul style="list-style-type: none">(i) contours(ii) depths(iii) angles(iv) distances(v) linear and angular measurement to layout

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. GENERAL PROCEDURES .

BLOCK 4: Fabrication

TABLE OF CONTENTS

UNIT 1: Fabricating Techniques	Page 31
2: Fitting and Assembly	35

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. GENERAL PROCEDURES .

BLOCK 4: Fabrication

UNIT 1: Fabricating Techniques

OPERATIONS	KNOWLEDGE
1. Making and repairing simple glass apparatus	<ul style="list-style-type: none">(a) Interpretation of drawings to determine size, shape and purpose of apparatus(b) Type, use and properties of glass(c) Effects of length on pressure and temperature rating(d) Size of standard glass tubing and sheet glass(e) Methods of making straight or circular cuts in sheet glass(f) Methods of drilling holes in sheet glass(g) Procedures for cutting glass tubing(h) Type and use of special glass working equipment for performing the following operations on glass tubing:<ul style="list-style-type: none">(i) shaping(ii) bending(iii) sealing(iv) fusing(v) burnishing(vi) annealing(i) Methods of grinding and polishing cut edges smooth(j) Type and use of metal connectors for glass tubing(k) Methods of sealing metal connectors on glass tubing(l) Procedures for making glass manometers(m) Type and use of gauge glass fittings(n) Importance and hazards of pressure testing(o) Techniques of proper tightening of glands and seal joints on glass tubes and gauge glasses(p) Type and use of cleaning fluids for glass(q) Methods of providing and setting indicating scales(r) Methods of mounting and protecting glass apparatus(s) Importance of proper handling of glass(t) Mathematics:<ul style="list-style-type: none">(i) linear measurement to calculate size(ii) properties of the circle for layout(iii) ratio, proportion, square root

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. GENERAL PROCEDURES .

BLOCK 4: Fabrication

UNIT 1: Fabricating Techniques

OPERATIONS	KNOWLEDGE
<hr/>	
1. Making and repairing simple glass apparatus (cont'd)	(u) Science: <ul style="list-style-type: none">(i) solvents(ii) elementary glass blowing(iii) thermal expansion and contraction
2. Making and repairing plastic apparatus	(a) Type, use and characteristics of common plastic materials (b) Standard sizes of plastic sheet, rod and tubing (c) Effects of temperature and chemicals on plastic materials (d) Identification of common plastics (e) Methods of cutting, drilling and forming plastic materials (f) Use of power and hand tools when working with plastic materials (g) Methods of assembly: <ul style="list-style-type: none">(i) bolts and screws(ii) adhesives (h) Type, purpose and use of plastic adhesives (i) Methods of making leak-proof joints (j) Methods of cleaning and polishing (k) Type of cleaning and polishing agents (l) Type, use and size of plastic fittings for tubing and small pipes (m) Use of pantograph machines for engraving laminated plastics (n) Type of laminated plastics (o) Mathematics: <ul style="list-style-type: none">(i) linear measurement for layout(ii) properties of angles and circles for layout (p) Science: <ul style="list-style-type: none">(i) solvents(ii) properties of plastics(iii) acids, bases, and salts

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. GENERAL PROCEDURES .

BLOCK 4: Fabrication

UNIT 1: Fabricating Techniques

OPERATIONS	KNOWLEDGE
3. Making or repairing small metal units or objects	<ul style="list-style-type: none">(a) Interpretation of drawings and specifications to determine:<ul style="list-style-type: none">(i) size(ii) shape(iii) material(b) Type and characteristics of common metals(c) Methods of performing the following operations on ferrous and non-ferrous metals:<ul style="list-style-type: none">(i) cutting(ii) drilling(iii) bending(iv) grinding(v) threading(vi) tapping(vii) reaming(viii) rectangular and circular hole cutting(ix) filing(d) Procedures for laying out work(e) Methods of forming objects from sheet metal(f) Use of small standard structural shapes for instrument supports, brackets, panel framework, linkages, etc.(g) Procedures for using round stock for making shafts linkages, pulleys, etc.(h) Methods of making instrument supports, linkages, pitot tubes, venturis' bubble pipes from tubular or pipe shapes(i) Type, care and use of soft and hard soldering equipment(j) Methods of making and repairing small instrument linkages(k) Considerations of the effect of corrosion in choice of material(l) Type of anti-corrosion coatings(m) Methods of fastening:<ul style="list-style-type: none">(i) bolts and screws(ii) rivets(iii) welding(n) Type, size and use of bolt and screw fasteners

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. GENERAL PROCEDURES.

BLOCK 4: Fabrication

UNIT 1: Fabricating Techniques

OPERATIONS	KNOWLEDGE
<hr/>	
3. Making or repairing small metal units or objects (cont'd)	(o) Methods of assembling or repairing small chain or cable links (p) Mathematics: (i) linear measurement for layout (ii) properties of circle and angles for layout (iii) ratio and proportion for calculating length of linkages (iv) geometric shapes for shaping and layout of floats. (q) Science: (i) physical properties of ferrous and non-ferrous metals and alloys (ii) linkages and levers (iii) bolted, rivetted and welded joints (iv) pulleys

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. GENERAL PROCEDURES .

BLOCK 4: Fabrication

UNIT 2: Fitting and Assembly

OPERATIONS

KNOWLEDGE

1. Fitting

- (a) Interpretation of drawings and specifications to determine:
 - (i) method of fitting
 - (ii) type of fit required
 - (iii) tolerance
 - (iv) types of surface finish
 - (v) types of material
- (b) Methods and types of fitting:
 - (i) hand
 - (ii) machine
- (c) Systems of fits and clearances:
 - (i) Canadian Standards Association
 - (ii) American Standards Association
 - (iii) Newell systems
- (d) Application of tolerances for dimensional control:
 - (i) unilateral
 - (ii) bilateral
 - (iii) basic hole system
 - (iv) basic shaft system
- (e) Application of fits and clearances
- (f) Use of machinist's handbook to determine:
 - (i) tap drill sizes
 - (ii) fits and clearances
- (g) Mathematics: to calculate -
 - (i) tolerances
 - (ii) allowances
 - (iii) limits
 - (iv) thermal expansion
 - (v) heat coefficients
- (h) Science:
 - (i) fits and clearances
 - (ii) characteristics of metals
 - (iii) heat treatment of metals
 - (iv) plastics: thermosetting and thermoplastics

. GENERAL PROCEDURES .

BLOCK 4: Fabrication

UNIT 2: Fitting and Assembly

OPERATIONS	KNOWLEDGE
<hr/>	
2. Fitting bearings	<ul style="list-style-type: none">(a) Interpretation of drawings and specifications to determine:<ul style="list-style-type: none">(i) bearing specification(ii) dimension(b) Type and characteristics of plain cylindrical journal bearings:<ul style="list-style-type: none">(i) bronze(ii) babbitt(iii) copper beryllium(iv) lead bronze, etc.(c) Methods and techniques of fitting plain journal bearings:<ul style="list-style-type: none">(i) use of reference tables(ii) types of bearing surfaces(iii) methods of alignment(iv) scraping and honing procedures(v) methods of producing oil grooves(vi) use of marking media(d) Method of testing bearing for clearance and allowance(e) Type of bearings with rolling contact:<ul style="list-style-type: none">(i) radial ball(ii) angular ball(iii) radial roller(iv) tapered roller(v) spherical race(vi) radial or thrust ball(vii) roller thrust(viii) special purposes, etc.(f) Methods of fitting rolling contact bearings(g) Lubrication required for bearings and bearing surfaces(h) Science:<ul style="list-style-type: none">(i) load characteristics of plain and rolling contact bearings(ii) heat coefficients for load and temperature operation(iii) nature of friction(iv) static and sliding friction(v) types of lubricants and their uses(vi) lubrication deterioration(vii) viscosity(viii) methods of lubrication(ix) metals for bearings

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. GENERAL PROCEDURES .

BLOCK 4: Fabrication

UNIT 2: Fitting and Assembly

OPERATIONS	KNOWLEDGE
3. Fitting jig and guide bushings	<ul style="list-style-type: none">(a) Interpretation of drawings and specifications to determine:<ul style="list-style-type: none">(i) location(ii) size(iii) material(b) Type, purpose and application of jig bushings(c) Use of reference handbook to determine fits and clearances(d) Methods of installing bushings:<ul style="list-style-type: none">(i) press(ii) force(iii) floating(e) Method of locating stops and position of bushings(f) Type and application of lubricants(g) Procedure for squaring, truing and locating bushings(h) Methods of inspecting after assembly(i) Procedure to correct size after assembly:<ul style="list-style-type: none">(i) grinding(ii) honing(j) Care and use of inspection tools(k) Mathematics:<ul style="list-style-type: none">(i) linear measurement to calculate size(ii) conversion of decimal and fractional values
4. Locating components	<ul style="list-style-type: none">(a) Interpretation of drawings and specifications to determine:<ul style="list-style-type: none">(i) position(ii) tooling points(iii) dimensions(b) Type and application of dowels(c) Methods of locating dowels and taper pins(d) Methods of installing and removing pins(e) Characteristics and use of roll pins for assembly purposes(f) Type and application of match plates for locating purposes(g) Care and use of layout and measuring tools

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. GENERAL PROCEDURES .

BLOCK 4: Fabrication

UNIT 2: Fitting and Assembly

OPERATIONS	KNOWLEDGE
<hr/>	
5. Fitting sliding parts	<ul style="list-style-type: none">(a) Interpretation of drawings and specifications to determine:<ul style="list-style-type: none">(i) type of fit(ii) dimensions and tolerance(iii) surface finish(b) Use of machinist's handbook and reference tables(c) Methods and procedure to obtain desired fit:<ul style="list-style-type: none">(i) marking media(ii) scraping(iii) honing(iv) lapping, etc.(d) Techniques for inspecting surface finish, alignment and flatness(e) Dimensional change during operation due to thermal expansion and contraction(f) Science:<ul style="list-style-type: none">(i) types of lubricants and their use(ii) surface quality of metals(iii) thermal expansion and contraction(iv) nature of friction(v) static and sliding friction

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. GENERAL PROCEDURES .

BLOCK 4: Fabrication

UNIT 2: Fitting and Assembly

OPERATIONS

KNOWLEDGE

6. Lapping

- (a) Type and use of lapping compounds
- (b) Use of jigs or special attachments for holding work
- (c) Use of hand or power operated lapping mechanisms
- (d) Methods of lapping by using mating forms or part of the work-piece
- (e) Importance of correct alignment of the lap and work-piece
- (f) Type of seating of mating surfaces
 - (i) flat
 - (ii) angle
 - (iii) sleeve
- (g) Importance of preparing mating surfaces by lathework or grinding where necessary
- (h) Effects of mating similar or different materials in lapping operations
- (i) Methods of testing lapping operations through use of dyes, etc.
- (j) Importance of cleanliness of work-piece and lapping equipment
- (k) Application of lapping methods to the seating of instrument control valves
- (l) Importance of pressure testing the finished job when tight shut-off is required
- (m) Limits of material removal in lapping operations
- (n) Importance of removing all lapping compound and cleaning work-piece after completion of lapping operation
- (o) Science:
 - (i) abrasive materials
 - (ii) fits and clearances
 - (iii) surface roughness measurement

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. GENERAL PROCEDURES .

BLOCK 4: Fabrication

UNIT 2: Fitting and Assembly

OPERATIONS	KNOWLEDGE
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7. Fastening metals	<ul style="list-style-type: none">(a) Type and use of threaded fastener:<ul style="list-style-type: none">(i) bolts and nuts(ii) cap screws(iii) machine screws(iv) sets screws(v) stud bolts(b) Type and use of washers:<ul style="list-style-type: none">(i) flat(ii) lock(c) Methods of installing threaded fasteners(d) Type and use of other fastening devices:<ul style="list-style-type: none">(i) rivets(ii) keys(iii) springs(iv) pins(v) welding(e) Methods and procedures for rivetting:<ul style="list-style-type: none">(i) hammer (hand)(ii) guns(iii) machines(f) Type, care and use of rivetting machines(g) Method and procedure for installing, keys, springs and pins(h) Type, use and care of welding machine:<ul style="list-style-type: none">(i) spot welding(ii) seam welding(iii) flash welding, etc.(i) Type, use and care of wire stapling and stitching machines(j) Type and use of fixtures for assembly(k) Type and use of lubricants used in assembly(l) Mathematics:<ul style="list-style-type: none">(i) calculation of torque required to tighten threaded fastener(m) Science:<ul style="list-style-type: none">(i) type of lubricants and their uses(ii) lubricant deterioration

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. GENERAL PROCEDURES .

BLOCK 4: Fabrication

UNIT 2: Fitting and Assembly

OPERATIONS	KNOWLEDGE
<hr/>	
8. Joining with plastics	<ul style="list-style-type: none">(a) Type and characteristics of plastics:<ul style="list-style-type: none">(i) thermosetting(ii) thermoplastic(b) Type of plastic joints(c) Methods of joining:<ul style="list-style-type: none">(i) heat(ii) cement(iii) machine(d) Type of application of jigs and fixtures for joining plastics(e) Procedures for bending plastics(f) Production assembly procedure(g) Science:<ul style="list-style-type: none">(i) plastics-thermosetting and thermoplastic(ii) synthetic rubber and fibers(iii) plastic cements and solvents

BLOCK 5: Installation & Services

TABLE OF CONTENTS

UNIT 1: Piping-Tubing-Raceways	Page 43
2: Electrical Wiring	50
3: Panels	54
4: Instruments	59
5: Instrument Air Supply Systems	61

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. GENERAL PROCEDURES .

BLOCK 5: Installation & Services UNIT 1: Piping-Tubing-Raceways

OPERATIONS	KNOWLEDGE
<hr/>	
1. Installing pipe runs	<ul style="list-style-type: none">(a) Interpretation of drawings and specifications to determine:<ul style="list-style-type: none">(i) purpose of run(ii) location of run(iii) fluid type(iv) fluid pressure(v) size(vi) material(b) Pipe sizes, schedules, and material(c) Type, size and application of pipe fittings and valves(d) Type and use of thread compounds(e) Methods used in performing the following operations:<ul style="list-style-type: none">(i) cutting(ii) threading(iii) drilling and tapping(iv) reaming(v) welding(f) Techniques of bending pipe(g) Importance and methods of measurement to determine:<ul style="list-style-type: none">(i) length(ii) slope(iii) joint allowance(iv) bend allowance(h) Methods of installing pipe(i) Importance of providing or avoiding traps in pipe runs(j) Procedures for installing pipe fitting(k) Importance of location of pipe fitting and valves in piping installation(l) Purpose and methods of installing:<ul style="list-style-type: none">(i) clean-outs(ii) by-passes(iii) sediment chambers(iv) instrument block valves(v) two and three valve instrument isolation and zeroing assemblies(vi) purging assemblies(vii) air vents(viii) brains

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. GENERAL PROCEDURES .

BLOCK 5: Installation & Services UNIT 1: Piping-Tubing-Raceways

OPERATIONS	KNOWLEDGE
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1. Installing pipe runs (cont'd)	<ul style="list-style-type: none">(m) Methods of fastening or hanging pipe to building or machinery structures(n) Effects of vibration(o) Importance of providing expansion allowances(p) Type of protective and insulating covering(q) Methods of steam or electric tracing of pipe(r) Type, purpose and material of construction for:<ul style="list-style-type: none">(i) pipe fittings(ii) pipe to tube fittings(iii) glass, plastic & hose connections(s) Methods of making connections to process lines:<ul style="list-style-type: none">(i) none pressurized(ii) pressurized(t) Importance of neatness when installing pipe runs(u) Type and correct use of ladders and staging(v) Importance and methods of flushing or cleaning lines after installation(w) Importance of testing runs for leakage(x) Type and use of leak test equipment(y) Mathematics:<ul style="list-style-type: none">(i) linear measurement for layout(ii) Pythagoras' theorem to calculate offsets(iii) calculation of properties of a circle for installation(iv) ratio and proportion for layout(z) Science:<ul style="list-style-type: none">(i) physical properties of ferrous and non-ferrous metals(ii) plastics-thermosetting and thermoplastics(iii) synthetic rubber(iv) thermal expansion and contraction(v) flow through pipes

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. GENERAL PROCEDURES .

BLOCK 5: Installation & Services UNIT 1: Piping-Tubing-Raceways

OPERATIONS	KNOWLEDGE
<hr/>	
2. Installing tubing runs	<ul style="list-style-type: none">(a) Interpretation of drawings and specifications to determine:<ul style="list-style-type: none">(i) uses of instrument schematics and identification(ii) purpose of run(iii) location of run(iv) fluid type pressure and temperature(v) size(vi) material(b) Type, use, material and sizes of tubing:<ul style="list-style-type: none">(i) metal and plastic(ii) single tube and multi-tube bundles(c) Type, use, size and threads of tubing connectors and fittings for:<ul style="list-style-type: none">(i) tube to tube(ii) plastic to metal tubing(iii) tubing to pipe(iv) tube to instrument(d) Considerations in measuring:<ul style="list-style-type: none">(i) length(ii) slope(iii) joint allowance(iv) bend allowance(e) Type and use of thread compounds(f) Methods used in performing the following functions:<ul style="list-style-type: none">(i) cutting(ii) cleaning or reaming of tube and after cutting(iii) bending(iv) hard and soft soldering(v) joining(vi) flaring(vii) straightening(viii) drilling and tapping(g) Purposes and methods of providing slope to tubing runs(h) Importance of correct bend radii(i) Methods of installing tubing to avoid trapping the fluid(j) Purposes and methods of installing:<ul style="list-style-type: none">(i) purging assemblies(ii) air vents(iii) two and three valve instrument isolation and zeroing assemblies

. GENERAL PROCEDURES .

BLOCK 5: Installation & Services UNIT 1: Piping-Tubing-Raceways

OPERATIONS

KNOWLEDGE

-
2. Installing tubing runs (cont'd)
- (k) Methods of fastening single or multi-tube runs to building or machinery structures and in raceways
 - (l) Methods of providing:
 - (i) expansion allowance
 - (ii) protection against mechanical damage and excessive vibration
 - (iii) insulation
 - (m) Application of anti-corrosion coatings such as:
 - (i) varnish
 - (ii) plastic
 - (iii) plastic sheath
 - (n) Methods of protecting plastic tubing against:
 - (i) mechanical damage
 - (ii) heat damage
 - (o) Methods of steam or electric tracing of metal tubing
 - (p) Procedures for connecting to process lines:
 - (i) none pressurized
 - (ii) pressurized
 - (q) Importance of neat runs
 - (r) Type and correct use of ladders and staging
 - (s) Type of fluids and methods used for flushing or cleaning tubing runs after installation
 - (t) Importance of testing runs for leaks after installation
 - (u) Type and use of leak test equipment
 - (v) Mathematics:
 - (i) linear measurement for layout
 - (ii) pythagoras' theorem to calculate offsets
 - (iii) calculation of properties of a circle for installation
 - (iv) ratio and proportion for layout
 - (w) Science:
 - (i) thermal expansion and contraction
 - (ii) flow through pipes
 - (iii) physical properties of plastics

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. GENERAL PROCEDURES .

BLOCK 5: Installation & Services UNIT 1: Piping-Tubing-Raceways

OPERATIONS

KNOWLEDGE

3. Installing raceways

- (a) Interpretation of drawings and specifications to determine:
 - (i) size and shape of raceway
 - (ii) material
 - (iii) length of run, number of branches, number of bends, number of tubes, and their size
- (b) Type, purpose and characteristic of raceways:
 - (i) light gauge sheet metal
 - (ii) standard structural extrusions
 - (iii) conduit
 - (iv) rack
 - (v) prefabricated
- (c) Materials of construction for raceways:
 - (i) galvanized sheet steel
 - (ii) steel and steel alloys
 - (iii) aluminum
 - (iv) plastic coated steel
 - (v) epoxy or fiber glass
- (d) Methods of attaching raceways to building or machinery structures
- (e) Type and application of protective coatings to raceways
- (f) Methods of joining raceways:
 - (i) welding
 - (ii) bolting
- (g) Methods of fabricating raceway out of sheet metal or standard extrusions
- (h) Procedures for forming bends and curves
- (i) Procedures for fastening single or multi-banked tubing in raceways
- (j) Methods of inserting tubing in conduits
- (k) Methods used to:
 - (i) drill and tap ferrous and non-ferrous metals
 - (ii) join ferrous and non-ferrous metals by bolting or welding
 - (iii) cut and bend ferrous and non-ferrous metals
 - (iv) layout and form sheet metal
- (l) Procedures for joining branch lines to raceways
- (m) Importance of protecting raceways from vibrating equipment

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. GENERAL PROCEDURES .

BLOCK 5: Installation & Services UNIT 1: Piping-Tubing-Raceways

OPERATIONS	KNOWLEDGE
3. Installing raceways (cont'd)	(n) Type and correct use of ladders and staging (o) Mathematics: (i) linear measurement to calculate size and length (ii) pythagoras' theorem to calculate offsets (iii) calculations to determine properties of circles and triangles for layout (iv) ratio and proportion to calculate dimensions
4. Maintaining piping, tubing and raceways	(a) Interpretation of drawings and specifications to determine: (i) purpose of run (ii) fluid type and pressure (iii) identification of run (b) Procedures used to detect air or gas leaks: (i) soap test (ii) chemical reaction (iii) special electronic or flame equipment (c) Hazards in checking for steam leaks or leakage of other dangerous fluids (d) Methods of detecting atmospheric, chemical, or electrolytic corrosion (e) Methods used for cleaning, purging, or blowing down the inside passage of pipes and tubes (f) Procedures used for dead-end testing of tube runs (g) Type, purpose and use of hydrostatic test equipment (h) Purpose and methods of replenishing sealing fluids (i) Methods of removing air or condensation from tube or pipe runs (j) Effects of typical industrial atmospheres (k) Type and method of applying protective coatings (l) Methods of removing broken pipe nipples and fittings

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. GENERAL PROCEDURES .

BLOCK 5: Installation & Services UNIT 1: Piping-Tubing-Raceways

OPERATIONS	KNOWLEDGE
4. Maintaining piping, tubing and raceways (cont'd)	<ul style="list-style-type: none">(m) Procedures for removing seized fittings and fasteners(n) Type, purpose and use of thread compounds(o) Methods used in performing the following operations:<ul style="list-style-type: none">(i) cutting(ii) cleaning or reaming tube ends after cutting(iii) threading(iv) flaring(v) drilling and tapping(vi) reaming(vii) joining(viii) bending(ix) straightening tubing(x) hard and soft soldering(xi) forming of sheet metal(p) Procedures for repairing small instrument isolation valves:<ul style="list-style-type: none">(i) type of valves(ii) type, use and material of stem packing(iii) techniques of tightening stem packing(q) Type and correct use of ladders and staging(r) Mathematics:<ul style="list-style-type: none">(i) linear measurement to calculate size and length(ii) Pythagoras' theorem to calculate offsets(iii) calculations to determine properties of circles and triangles for layout(iv) ratio and proportion to calculate dimensions(s) Science:<ul style="list-style-type: none">(i) electrolysis(ii) atmospheric and galvanic corrosion(iii) characteristics of solids, liquids and gases(iv) density, specific gravity(v) flow through pipes(vi) pressure due to head(vii) thermal expansion and contraction

. GENERAL PROCEDURES .

BLOCK 5: Installation & Services UNIT 2: Electrical Wiring

OPERATIONS	KNOWLEDGE
1. Installing electric wiring	<ul style="list-style-type: none"> (a) Interpretation of drawings and specifications to determine: <ul style="list-style-type: none"> (i) purpose of circuit (ii) applicable electrical quantities (iii) wire size, shielding and type of carrier (iv) termination or end connection details (b) Interpretation of instrument manufacturer's literature and electrical code to determine: <ul style="list-style-type: none"> (i) the recommended installation of power, signal, control and alarm lines (ii) restrictions regarding the quantity of wires per conduit (c) Type, use, purpose, size and characteristics of: <ul style="list-style-type: none"> (i) wire and cable (ii) flexible and rigid conduit (iii) armoured metallic or metallic tubing systems (d) Type, size, purpose and application of: <ul style="list-style-type: none"> (i) conduit and conduit fittings (ii) function boxes (iii) wire, wire insulation and wire shielding (iv) terminal connections (e) Procedures for cutting, stripping insulation and joining single or multistrand wire (f) Methods used to join special types of signal runs: <ul style="list-style-type: none"> (i) thermocouple wire (ii) shielded multi-wire cables (g) Type and use of soldering equipment (h) Methods of supporting conduit runs from building and machinery structures (i) Procedures for installing signal runs to avoid electro-magnetic interference from nearby electrical equipment or high power conduit runs, such as: <ul style="list-style-type: none"> (i) choice of route (ii) shielding (iii) special grounding techniques

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. GENERAL PROCEDURES .

BLOCK 5: Installation & Services UNIT 2: Electrical Wiring

OPERATIONS	KNOWLEDGE
<hr/>	
1. Installing electric wiring (cont'd)	(j) Methods of pulling wire through conduits (k) Type, use and application of sealing compounds in conduit runs, junction boxes, and terminal boxes (l) Procedures used in checking electrical runs for: (i) continuity (ii) grounding (iii) insulation (m) Methods of measuring: (i) voltage (ii) amperage (iii) resistance (iv) impedance (n) Importance of checking the completed installation (o) Type and correct use of ladders and staging (p) Mathematics: (i) linear measurement to calculate length and size (ii) formula to calculate electrical values (iii) ratio and proportion for layout (q) Science: (i) elementary electrical theory, measurement, and circuitry (ii) acids, bases, salts, neutraliza- tion, pH scale and hydrolysis (iii) low voltage-high impedance circuitry

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. GENERAL PROCEDURES .

BLOCK 5: Installation & Services UNIT 2: Electrical Wiring

OPERATIONS	KNOWLEDGE
<hr/>	
2. Maintaining electric wiring	<ul style="list-style-type: none">(a) Interpretation of drawings and specifications to determine:<ul style="list-style-type: none">(i) purpose of circuit(ii) applicable electrical quantities(iii) wire size, shielding and type of carrier(iv) termination or end connections details .(b) Interpretation of instrument manufacturer's literature and electrical code to determine:<ul style="list-style-type: none">(i) recommended installation of power signal, control and alarm lines(ii) restrictions regarding the quantity of wires per conduit(c) Methods and equipment used to check faults such as:<ul style="list-style-type: none">(i) high resistance(ii) shorts(iii) grounds(iv) shielding breaks(d) Type of instruments and methods used to check insulation faults(e) Methods of detecting and preventing moisture faults at joints or terminals(f) Type and use of sealing compounds(g) Type and application of protective coatings or covering of conduits against industrial atmospheres such as:<ul style="list-style-type: none">(i) water vapor(ii) chlorine gas(iii) sulphur dioxide gas(h) Procedures for preventing corrosion faults at joints or terminals(i) Methods of joining or splicing wire(j) Special methods of joining signal wires such as:<ul style="list-style-type: none">(i) Thermocouple wire(ii) shielded multi-wire cables(k) Methods used to strip insulation off wire(l) Methods of replacing wires in conduits(m) Type and correct use of ladders and staging(n) Hazards of electrical shocks

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. GENERAL PROCEDURES .

BLOCK 5: Installation & Services UNIT 2: Electrical Wiring

OPERATIONS	KNOWLEDGE
<hr/>	
2. Maintaining electric wiring (cont'd)	(o) Mathematics: <ul style="list-style-type: none">(i) linear measurement for layout(ii) Pythagoras' theorem to calculate offsets(iii) calculation of properties of a circle for installation(iv) ratio and proportion for layout (p) Science: <ul style="list-style-type: none">(i) elementary electrical theory, measurement, and circuitry(ii) acids, bases, salts, neutralization, pH scale and hydrolysis(iii) low voltage—high impedance circuitry

. GENERAL PROCEDURES .

BLOCK 5: Installation & Services UNIT 3: Panels

OPERATIONS	KNOWLEDGE
1. Fabricating panels	<ul style="list-style-type: none"> (a) Interpretation of drawings and specifications to determine: <ul style="list-style-type: none"> (i) size and shape of panel (ii) cut-outs (iii) method of support (iv) internal structure (v) material . (vi) material gauge or thickness (vii) finish (b) Methods of performing the following operations on sheet metal: <ul style="list-style-type: none"> (i) layout (ii) drilling (iii) cutting circular and rectangular holes (iv) filing (v) general welding (vi) spot welding (vii) forming or bending (viii) grinding (ix) buffing (x) finishing (c) Procedures to cut or shape materials such as: <ul style="list-style-type: none"> (i) plastic (ii) stainless steels (iii) aluminum (d) Methods of framing or reinforcing panels with standard structural extrusions (e) Type, purpose and styles of panels: <ul style="list-style-type: none"> (i) vertical or up-right (ii) console (iii) combination of (i) and (ii) (iv) cubical or non-cubical (f) Methods of assembling panels by: <ul style="list-style-type: none"> (i) welding (ii) bolting (g) Type and method of providing maintenance access to cubical panels such as: <ul style="list-style-type: none"> (i) removable plates (ii) doors

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. GENERAL PROCEDURES .

BLOCK 5: Installation & Services UNIT 3: Panels

OPERATIONS	KNOWLEDGE
<hr/>	
1. Fabricating panels (cont'd)	<ul style="list-style-type: none">(h) Methods of isolating electrical components from pneumatic components:<ul style="list-style-type: none">(i) providing separate compartments(ii) providing barriers(i) Type of quick release fasteners for panel access plates(j) Methods of providing appertures for tubing and electrical conduit(k) Materials used for sealing, tubing, conduit appertures, doors and access plates(l) Purpose and application of sealing materials(m) Purpose and types of bulkhead supports for tubing and electrical conduits(n) Methods of providing for and attaching panel supports(o) Mathematics:<ul style="list-style-type: none">(i) linear measurement to calculate length and size(ii) triangle and circle for layout

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. GENERAL PROCEDURES .

BLOCK 5: Installation & Services UNIT 3: Panels

OPERATIONS	KNOWLEDGE
2. Installing panel accessories	<ul style="list-style-type: none">(a) Type, purpose and methods of fabricating tubing and electrical conduit bulkheads(b) Type, purpose and characteristics of bulkhead fittings(c) Methods of installing bulkhead fittings(d) Methods of installing air supply headers(e) Component parts and methods of installing instrument power supplies such as:<ul style="list-style-type: none">(i) wiring(ii) fuses(iii) main-dis-connects(iv) instrument dis-connects(v) terminal connections(f) Methods of providing frontal illumination such as extended canopies(g) Importance of providing internal illumination and grounded female plugs for electrical maintenance tools(h) Methods of connecting air purging or ventilating systems to closed panels(i) Fabrication and installation of brackets and instrument racks in panels(j) Methods and tools used to perform the following operations:<ul style="list-style-type: none">(i) layout(ii) drilling and tapping(iii) cutting and threading pipe(iv) cutting and threading conduit(v) cutting and flaring tubing(vi) cutting wiring(vii) insulation stripping of wiring(viii) joining pipe, tubing and conduit(ix) connecting wiring(x) forming or bending sheet metal(xi) general and spot welding(k) Type and use of fasteners such as:<ul style="list-style-type: none">(i) bolts and machine screws(ii) sheet metal bolts and screws(l) Mathematics:<ul style="list-style-type: none">(i) linear measurement to calculate length and size(ii) calculation of properties of circle and angles for layout(m) Science: elementary electric theory and circuitry

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. GENERAL PROCEDURES .

BLOCK 5: Installation & Services UNIT 3: Panels

OPERATIONS	KNOWLEDGE
<hr/>	
3. Installing panels	<ul style="list-style-type: none">(a) Interpretation of drawings and specifications to determine:<ul style="list-style-type: none">(i) location(ii) type of support(b) Type of panel mounting:<ul style="list-style-type: none">(i) wall(ii) pedestal(iii) floor(c) Methods of installing panels(d) Special methods and equipment used to attach fasteners to concrete or structural steel(e) Methods used to bend standard metal shapes such as flat and round stock(f) Methods and types of mounting used to dampen the effects of vibration(g) Type of fasteners to join panel sections(h) Type, care and use of equipment to lift panels into position(i) Methods of aligning panels, vertically and horizontally(j) Procedures for grouting-in panels on concrete curbs(k) Type of extended canopies used for frontal illumination and protection(l) Methods and procedures for attaching extended canopies(m) Mathematics:<ul style="list-style-type: none">(i) linear measurement for layout(ii) calculation of angles(n) Science:<ul style="list-style-type: none">(i) mechanical advantage of simple machines(ii) levers and screw jack(iii) pulley blocks(iv) factor of safety

. GENERAL PROCEDURES .

BLOCK 5: Installation & Services UNIT 3: Panels

OPERATIONS	KNOWLEDGE
4. Maintaining panels	<ul style="list-style-type: none"> (a) Type, purpose and use of panel seals for: <ul style="list-style-type: none"> (i) panel joints (ii) floors (iii) access plates (iv) tubing or conduit openings (b) Methods of repairing panel seals (c) Effects of typical industrial atmospheres such as: <ul style="list-style-type: none"> (i) water vapor (ii) chlorine gas (iii) sulfur dioxide gas (d) Type and method of repairing door hinges and panel fasteners (e) Methods used for removing seized fasteners such as: <ul style="list-style-type: none"> (i) drilling (ii) cutting (iii) penetrating liquids (iv) heat (f) Importance of checking the cleanliness of the air used for forced ventilating or purging of panels (g) Application and types of surface finishes such as: <ul style="list-style-type: none"> (i) rust inhibitors (ii) paint (iii) plastic (h) Methods and importance of preparing the panel surface before the application of surface finishes (i) Methods of protecting panels against excessive vibration (j) Methods of fabricating instrument cutout blanks (k) Methods of installing and fastening instrument cutout blanks (l) Procedures for attaching instrument nameplates to panel surfaces such as: <ul style="list-style-type: none"> (i) special cementing compounds (ii) screw fasteners (m) Mathematics: <ul style="list-style-type: none"> (i) linear measurement for layout (ii) calculation of properties of circle and angles (n) Science: <ul style="list-style-type: none"> (i) corrosion (ii) humidity

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. GENERAL PROCEDURES .

BLOCK 5: Installation & Services UNIT 4: Instruments

OPERATIONS

KNOWLEDGE

1. Installing instrments

- (a) Interpretation of drawings and specifications to determine:
 - (i) identification
 - (ii) location
 - (iii) service connections
 - (iv) signal connections
 - (v) control connections
 - (vi) mounting method
- (b) Interpretation of manufacturer's literature to determine:
 - (i) maintenance clearances
 - (ii) mounting style
 - (iii) weight
 - (iv) control, signal and service connections
- (c) Purpose and type of instrment manufacturer's panel mounting brackets
- (d) Methods of fabricating instrment mounting brackets for wall or pedestal mounting
- (e) Methods and importance of aligning instruments vertically and horizontally
- (f) Type and standard of bolt and screw fasteners
- (g) Procedures for installing studs in concrete walls
- (h) Type, size and material of studs used in concrete
- (i) Importance of protecting instrument supports from corrosion by:
 - (i) choice of material
 - (ii) surface protection
- (j) Type, purpose and size of instrument pipe and tube connectors
- (k) Techniques for installing pipe and tube connectors
- (l) Effects of improper installation of pipe or tube fittings in instrument castings
- (m) Type and limitation in the use of thread sealing compounds on instrument connections

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. GENERAL PROCEDURES .

BLOCK 5: Installation & Services UNIT 4: Instruments

OPERATIONS	KNOWLEDGE
<hr/>	
1. Installing instruments (cont'd)	(n) Methods of connecting rigid or flexible carriers of electrical power or signal leads (o) Use of short plug-in cords for supplying electric power to instruments (p) Preparation of electric power or signal leads for attaching to instrument terminals (q) Methods of connecting shielded signal wires (r) Importance of proper ground connections (s) Typical methods of providing partial or complete protective enclosures for field or local mounted instruments (t) Methods of mounting instruments on process lines or equipment (u) Methods of preventing damage, caused by vibration, to instruments or instrument connecting lines (v) Mathematics: (i) linear measurement to calculate dimensions (ii) calculation of properties of circle and triangle for layout (w) Science: (i) corrosion and corrosive atmospheres (ii) AC & DC electrical circuitry

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. GENERAL PROCEDURES .

BLOCK 5: Installation & Services UNIT 5: Instrument Air Supply Systems

OPERATIONS	KNOWLEDGE
<hr/>	
1. Servicing plant systems	<ul style="list-style-type: none">(a) Interpretation of drawings and specifications to determine:<ul style="list-style-type: none">(i) location of main compressors and auxilliary units(ii) location and size of main supply headers(iii) location and size of branch lines(iv) location, size and type of main header and branch line isolating valves(b) Type, purpose and use of typical instrument air compressors(c) Interpretation of manufacturer's literature on air compressors(d) Purpose and operation of compressor inter-coolers and after-coolers(e) Importance of oil and moisture-free instrument air(f) Methods and equipment used for drying air(g) Type, purpose and use of air receivers(h) Type and use of safety valves on compressor air coolers and receivers(i) Importance of periodic draining of air receivers(j) Methods of measuring dew point(k) Methods of measuring air flow rates(l) Methods of controlling system pressure such as:<ul style="list-style-type: none">(i) compressor unloading valves(ii) prime mover control(m) Interpretation of manufacturer's literature to determine air consumption rates of typical instrument components(n) Type of distribution(o) Advantages of plant and department loops in distribution systems

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. GENERAL PROCEDURES .

BLOCK 5: Installation & Services UNIT 5: Instrument Air Supply Systems

OPERATIONS	KNOWLEDGE
<hr/>	
1. Servicing plant systems (cont'd)	<ul style="list-style-type: none">(p) Advantages of taking branch lines from the top of main headers(q) Type and construction of main and branch line isolating valves(r) Methods of repairing isolating valves(s) Hazards in repairing compressed air systems because of:<ul style="list-style-type: none">(i) expansion rate of air through jets(ii) oil-air mixtures and their ignition point(t) Type, use and common size of pressure regulators such as:<ul style="list-style-type: none">(i) safety valves(ii) instrment controlled(iii) self-actuated regulators(u) Methods of sizing pressure regulators(v) Procedures for maintaining pressure regulators(w) Methods of repairing and maintaining auxillary equipment of distribution systems such as:<ul style="list-style-type: none">(i) typical water trap(ii) typical filter stations(x) Mathematics:<ul style="list-style-type: none">(i) linear measurement for layout(ii) area and volume measurement(iii) calculation of properties of circles and angles(iv) powers and roots(v) graphs(y) Science:<ul style="list-style-type: none">(i) fluid flow(ii) compression and expansion of gases(iii) temperature measurement(iv) humidity measurement

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. GENERAL PROCEDURES .

BLOCK 6: Test Equipment and Standards

TABLE OF CONTENTS

UNIT 1: General Procedures	Page 64
2: Temperature	66
3: Pressure	68
4: Volume & Weight	69
5: Flow	70
6: Time and Motion	71
7: Electrical Quantities	72
8: Miscellaneous Quantities	74

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. GENERAL PROCEDURES .

BLOCK 6: Test Equipment and Standards

UNIT 1: General Procedures

OPERATIONS	KNOWLEDGE
<hr/>	
1. Comparing field instruments to required standards	<ul style="list-style-type: none">(a) Interpretation of drawings and manufacturer's inspection manuals to determine:<ul style="list-style-type: none">(i) range and accuracy of field instrument(ii) range, accuracy and selection of test equipment and standard(iii) legal or ethical recommended standard of accuracy(iv) type of connection(v) services required(b) Interpretation of recommended standards and symbols by:<ul style="list-style-type: none">(i) National Research Council(ii) Department of Weights and Measures(iii) Canadian Standards Association(iv) Bureau of Standards(v) other relevant industrial standards(c) Importance of awareness of types of absolute standards as kept by Bureau of Standards(d) Importance of care when storing standards(e) Techniques of comparing instruments to standards in field installation(f) Techniques of comparing instruments to standards in a shop or laboratory(g) Importance of awareness to ambient considerations(h) Importance of absolute measurement(i) Methods and importance of checking:<ul style="list-style-type: none">(i) circuit polarity(ii) power source(iii) environmental (e.g. magnetic field, vibration, etc.)(j) Techniques of piping and connecting test and standard instruments(k) Techniques of wiring and connecting test and standard instruments(l) Importance of shielding and grounding in testing and calibration

. GENERAL PROCEDURES .

BLOCK 6: Equipment and
Standards

UNIT 1: General Procedures

1. Comparing field instruments to required standards (cont'd)
 - (m) Methods of adjusting compared instruments to standard instrument readings
 - (n) Techniques of reading instruments - importance of avoiding parallax
 - (o) Importance and effect of meniscus when reading liquid columns
 - (p) Procedures for plotting and presenting corrections to calibrated instruments
 - (q) Importance of awareness of hazards owing to:
 - (i) toxic materials
 - (ii) radiation
 - (iii) pressure
 - (iv) hot or cold materials
 - (v) explosive and inflammable materials
 - (r) Techniques of cleaning and handling mercury
 - (s) Importance of checking instruments for correct function
 - (t) Mathematics:
 - (i) linear and angular measurement
 - (ii) powers, roots
 - (iii) calculation of errors
 - (iv) interpolation
 - (v) graphs
 - (vi) conversion of scales
 - (u) Science:
 - (i) A.C. and D.C. circuitry
 - (ii) ammeter - voltmeter - ohmmeter
 - (iii) power, energy
 - (iv) conversion of metric and British systems of measures
 - (v) magnetism, electro-magnetism
 - (vi) static electricity
 - (vii) vibration
 - (viii) radiation
 - (ix) surface tension
 - (x) flash point
 - (xi) melting & boiling points

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. GENERAL PROCEDURES .

BLOCK 6: Test Equipment and
Standards

UNIT 2: Temperature

OPERATIONS	KNOWLEDGE
<hr/>	
1. Using temperature standards and test equipment	<ul style="list-style-type: none">(a) Type, purpose, principle of operation, care and use of test instruments<ul style="list-style-type: none">(i) laboratory type, liquid filled, comparison thermometer(ii) test standard dial thermometer(iii) resistance thermometer bulb(iv) thermocouple(v) pyrometric cones(vi) boiling and melting point standards(vii) potentiometers(viii) bridges(ix) others(b) Techniques of using standard temperature test equipment(c) Techniques of adjusting, servicing and calibrating test instruments(d) Importance of care when comparing temperature measurement at high or low absolute temperatures(e) Type, purpose and techniques of using heat sinks for temperature instrument comparison(f) Type and technique of using temperature baths<ul style="list-style-type: none">(i) oil(ii) salt(iii) solid metal(iv) other liquids(g) Importance of effect of radiation, convection or conduction in temperature measurements(h) Techniques of handling and caring for capillary tubing and sensing bulbs(i) Type, purpose and use of thermal insulating materials(j) Mathematics:<ul style="list-style-type: none">(i) ratios, powers, roots(ii) interpolation(iii) conversions

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. GENERAL PROCEDURES .

BLOCK 6: Test Equipment and
Standards

UNIT 2: Temperature

OPERATIONS

KNOWLEDGE

1. Using temperature standards
and test equipment (cont'd)

(k) Science:

- (i) heat transfer
- (ii) melting points
- (iii) boiling points
- (iv) freezing points
- (v) thermal E.M.F.
- (vi) Ohms Law
- (vii) potentiometers and bridges
- (viii) gas laws
- (ix) thermal expansion

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. GENERAL PROCEDURES .

BLOCK 6: Test Equipment and Standards

UNIT 3: Pressure

OPERATIONS	KNOWLEDGE
1. Using pressure standards and test equipment	<ul style="list-style-type: none">(a) Type, purpose, principle of operation, care and use of pressure test instruments:<ul style="list-style-type: none">(i) manometers(ii) dead weight testers(iii) standard weights(iv) draft gauges(v) alphanatron(vi) standard test gauges(vii) pressure cells (load cells)(viii) vacuum test apparatus(ix) electronic switch(x) others(b) Techniques of adjusting and servicing or calibrating pressure test instruments(c) Techniques of using standard pressure test instruments(d) Importance of care when measuring high pressures(e) Techniques of handling and caring for capillary tubing(f) Type, purpose and use of couplings and connectors when checking pressure instruments(g) Type, purpose and application of sampling devices(h) Importance of awareness to leaks when measuring vacuum(i) Procedures in testing for leaks(j) Mathematics:<ul style="list-style-type: none">(i) ratios, powers, roots(ii) interpolation(iii) conversions(k) Science:<ul style="list-style-type: none">(i) gas laws(ii) linear and volumetric expansion(iii) compressibility(iv) hydrostatics(v) specific gravity, density(vi) mass, force, weight(vii) acceleration, gravity(viii) Pascal's principle

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. GENERAL PROCEDURES .

BLOCK 6: Test Equipment and
Standards

UNIT 4: Volume and Weight

OPERATIONS

KNOWLEDGE

1. Using volume and weight
standards and test equipment

- (a) Type, purpose, principle of operation, care and use of test volume and weight measuring instruments:
 - (i) standard volume and weight measures
 - (ii) standard weights
 - (iii) displaced volume devices
 - (iv) others
- (b) Techniques of adjusting, servicing or calibrating weight and volume measuring instruments
- (c) Techniques of using standard volume and weight measuring instruments
- (d) Mathematics:
 - (i) linear and volumetric measurements
 - (ii) powers, roots, ratios
- (e) Science:
 - (i) mass, force, weight and acceleration
 - (ii) gas laws
 - (iii) specific gravity, density
 - (iv) thermal expansion

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. GENERAL PROCEDURES .

BLOCK 6: Test Equipment and Standards

UNIT 5: Flow

OPERATIONS	KNOWLEDGE
<hr/>	
1. Using flow test equipment and standards	<ul style="list-style-type: none">(a) Type, purpose, principle of operation care and use of test flow instruments<ul style="list-style-type: none">(i) manometers(ii) orifices(iii) weigh tanks(iv) gasometers(v) standard volume and weight measures(vi) weirs(vii) others(b) Technique of adjusting, servicing and calibrating test flow instruments(c) Techniques of using test flow instruments(d) Importance of care when checking flow of fluids at high pressure or temperature(e) Techniques of cleaning and handling mercury(f) Type, purpose and use of couplings, connectors and components(g) Importance of awareness to leaks when measuring differential pressures(h) Procedures for testing connecting lines for leaks(i) Mathematics:<ul style="list-style-type: none">(i) linear and volumetric measurement(ii) ratios, roots, powers(iii) interpolation(j) Science:<ul style="list-style-type: none">(i) gas laws(ii) linear and volumetric expansion(iii) compressibility(iv) fluid flow(v) density, specific gravity(vi) velocity, acceleration(vii) force, mass, weight

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. GENERAL PROCEDURES .

BLOCK 6: Test Equipment and Standards

UNIT 6: Time and Motion

OPERATIONS

KNOWLEDGE

1. Using time and motion test equipment and standards

- (a) Type, purpose, principle of operation, care and use of test instruments:
 - (i) standard stop watch
 - (ii) fixed gear ratios and synchronous motors
 - (iii) standard electronic counters
 - (iv) oscilloscope
 - (v) stroboscope
 - (vi) counters
 - (vii) tachometers
 - (viii) others
- (b) Technique of adjusting, servicing and calibrating test time and motion instruments
- (c) Techniques of using test time and motion instruments
- (d) Importance of care and accuracy when checking time and motion instruments
- (e) Importance and techniques of dividing lost motion and backlash in connection to time and motion measuring instruments
- (f) Mathematics:
 - (i) linear and angular measurements
 - (ii) ratios, roots and powers
 - (iii) interpolation
- (g) Science:
 - (i) distance, time and velocity relationships
 - (ii) gravity and acceleration
 - (iii) friction
 - (iv) gears, linkages and mechanisms
 - (v) simple motion
 - (vi) basic electronics
 - (vii) basic electricity
 - (viii) concept of phase and frequency
 - (ix) oscillators and amplifiers
 - (x) E.M.F. generators

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. GENERAL PROCEDURES .

BLOCK 6: Test Equipment and
Standards

UNIT 7: Electrical Quantities

OPERATIONS	KNOWLEDGE
<hr/>	
1. Using electrical quantities, standards and test equipment	<ul style="list-style-type: none">(a) Type, purpose, principle of operation, care and use of electrical quantities measuring instruments:<ul style="list-style-type: none">(i) standard cell(ii) decade boxes (R, L, C)(iii) potentiometers(iv) bridges(v) oscillators(vi) amplifiers(vii) oscilloscopes(viii) ohmmeters(ix) voltmeters(x) ammeters(xi) power and energy meters(xii) phase meters(xiii) vacuum tube testers(xiv) semiconductor testers(xv) others(b) Techniques of using standard electrical quantity measuring instruments(c) Techniques of adjusting, servicing and calibrating test instruments(d) Importance of care when comparing electrical quantities at high voltage(e) Methods and equipment to test electrical power supply(f) Importance of shielding, and grounding when measuring electrical quantities(g) Effect of stray signals on electrical measurements(h) Techniques of soldering and connecting electrical conductors and components(i) Type, purpose and use of insulators(j) Mathematics:<ul style="list-style-type: none">(i) ratios, powers, roots(ii) interpolation(iii) conversions(iv) trigonometrical functions(v) angular measurements

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. GENERAL PROCEDURES .

BLOCK 6: Test Equipment and
Standards

UNIT 7: Electrical Quantities

OPERATIONS

KNOWLEDGE

1. Using electrical quantities,
standards and test equipment
(cont'd)

(k) Science:

- (i) Ohms law
- (ii) theory of electron flow
- (iii) electronic tubes
- (iv) transistors and semiconductors
- (v) oscillators
- (vi) amplifiers
- (vii) potentiometers and bridges
- (viii) ammeter - voltmeter - ohmmeter
- (ix) cathode ray tubes
- (x) energy, power
- (xi) conductors and insulators

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. GENERAL PROCEDURES .

BLOCK 6: Test Equipment and Standards

UNIT 8: Miscellaneous Quantities

OPERATIONS	KNOWLEDGE
<hr/>	
1. Using miscellaneous quantities, test, equipment and standards	<ul style="list-style-type: none">(a) Type, purpose, principle of operation, care and use of following miscellaneous test instruments:<ul style="list-style-type: none">(i) sling psychometers(ii) dew point meters(iii) relative humidity meters(iv) viscosity meters(v) torque measuring devices(vi) Orsat meter(vii) pH buffer solutions(viii) pH meter(ix) light meter(x) vibration measuring devices(xi) hardness testers(b) Techniques of adjusting, servicing, calibrating and using test instruments(c) Importance of applying corrections to standard measuring instruments(d) Mathematics:<ul style="list-style-type: none">(i) linear and angular measurement(ii) loganths (for pH relationship)(iii) roots and power(iv) temperature conversions, graphs(e) Science:<ul style="list-style-type: none">(i) dew point or humidity(ii) viscosity(iii) torque, moments, force(iv) illumination(v) vibration(vi) stress, strain(vii) acidity and alkalinity

BLOCK 7: Temperature

TABLE OF CONTENTS

UNIT 1: Glass Thermometers	Page 76
2: Bimetallic Thermometers	80
3: Filled System Thermometers	83
4: Pyrometry	87
5: Resistance Thermometry	99

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 7: Temperature

UNIT 1: Glass Thermometers

OPERATIONS	KNOWLEDGE
<hr/>	
1. Installing glass thermometers	<ul style="list-style-type: none">(a) Interpretation of drawings and specifications to determine:<ul style="list-style-type: none">(i) type, size and location of thermowell(ii) type and size of thermometer(iii) temperature range(b) Operating conditions:<ul style="list-style-type: none">(i) medium, chemical composition(ii) pressure and temperature(iii) vibration(c) Importance of protecting thermometer against direct radiation and mechanical damage(d) Methods of installing thermowells(e) Use and limitations of thermowells(f) Techniques, materials and equipment to weld, braze or solder(g) Type, size and shape of glass thermometers(h) Type of expanding fluids used in glass thermometers:<ul style="list-style-type: none">(i) mercury(ii) alcohol(iii) others(i) Type of scales:<ul style="list-style-type: none">(i) centigrade(ii) fahrenheit(iii) others(j) Methods of installing glass thermometers in thermowells or protective devices(k) Care in handling glass thermometers(l) Techniques and materials used in reducing thermal resistance:<ul style="list-style-type: none">(i) fluids(ii) pastes(iii) foils(iv) others(m) Type, purpose and use of glands, packing materials and connectors(n) Importance of checking glass thermometers for correct operation(o) Mathematics:<ul style="list-style-type: none">(i) linear and angular measurements for installation(ii) temperature scales and conversions

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 7: Temperature

UNIT 1: Glass Thermometers

OPERATIONS

KNOWLEDGE

- | | |
|--|--|
| 1. Installing glass thermometers
(cont'd) | (p) Science:
(i) thermal expansion of materials
(ii) heat conduction
(iii) solders and fluxes |
|--|--|

. MEASUREMENT .

BLOCK 7: Temperature

UNIT 1: Glass Thermometers

OPERATIONS	KNOWLEDGE
2. Calibrating glass thermometers	<ul style="list-style-type: none"> (a) Interpretation of manufacturer's specifications to determine: <ul style="list-style-type: none"> (i) range (ii) accuracy and linearity (iii) type of calibration (b) Type, purpose and application of constant temperature mediums: <ul style="list-style-type: none"> (i) oil baths (ii) salt baths (iii) metal blocks (c) Methods of calibration: <ul style="list-style-type: none"> (i) absolute (ii) comparative (d) Procedures for immersion of thermometers for calibration (e) Effect and importance of correct immersion (f) Type, purpose and application of standard thermometers and references: <ul style="list-style-type: none"> (i) primary standards (ii) secondary standards (g) Methods of applying corrections caused by errors due to: <ul style="list-style-type: none"> (i) ambient pressure (ii) installation (iii) differential coefficients of expansion (h) Procedures in determination of time constant of a thermometer (i) Limitations and disadvantages of glass thermometers: <ul style="list-style-type: none"> (i) read at point of measurement (ii) fragility (iii) column separation (j) Mathematics: <ul style="list-style-type: none"> (i) conversion temperature scale (k) Science: <ul style="list-style-type: none"> (i) thermal expansion (ii) vapour pressure (iii) Charles' and Boyle's law (iv) elementary scientific measurements (v) international temperature scale

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 7: Temperature

UNIT 1: Glass Thermometers

OPERATIONS	KNOWLEDGE
<hr/>	
3. Maintaining and servicing thermometers	<ul style="list-style-type: none">(a) Interpretation of service manuals and manufacturers' specifications to determine:<ul style="list-style-type: none">(i) type and function of thermometer(ii) type and location of protective device(iii) suggested procedures for cleaning thermometers and thermowells(iv) recommended procedures for replacement and repair of thermometers(b) Service considerations(c) Care and use of organic solvents(d) Importance of adequate ventilation and fire protection when handling organic solvents(e) Methods of cleaning thermometers and protective devices(f) Procedures for replacement of glass thermometers(g) Care in handling glass thermometers(h) Importance of adequate protection against spilling mercury over hot objects in case of breakage of mercury glass thermometers(i) Care and health hazards in dealing with mercury(j) Techniques of repairing thermometers with "split" column(k) Importance of checking calibration of thermometers prior to installation or replacement(l) Mathematics:<ul style="list-style-type: none">(i) linear and angular measurements(ii) temperature scales and conversions(m) Science:<ul style="list-style-type: none">(i) linear and volumetric expansion(ii) thermal conductivity(iii) heat transfer(iv) solvents

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 7: Temperature

UNIT 2: Bimetallic Thermometers

OPERATIONS	KNOWLEDGE
<hr/>	
1. Installing bimetallic thermometer	<ul style="list-style-type: none">(a) Interpretation of drawings and specifications to determine - type, material and location of well(b) Use and limitations of thermowells(c) Type, material, purpose and use of metal expansion thermometers:<ul style="list-style-type: none">(i) differential metal(ii) bimetallic(iii) differential semi-metal(iv) direct expansion(d) Type of display:<ul style="list-style-type: none">(i) indicating dial type(ii) direct recording (mechanical input)(e) Type of scales:<ul style="list-style-type: none">(i) Centigrade(ii) Fahrenheit(f) Type, material, form and application of actuation mechanisms:<ul style="list-style-type: none">(i) springs(ii) coils(iii) spirals(iv) strips(g) Operating conditions:<ul style="list-style-type: none">(i) medium, chemical composition(ii) temperature, pressure(iii) vibration(h) Methods of installation of bimetallic thermometers(i) Type and application of glands and gland packing material(j) Methods of protection of thermometers from mechanical damage(k) Methods of checking thermometers for correct function and operation(l) Mathematics:<ul style="list-style-type: none">(i) linear measurement for layout(ii) temperature conversion(m) Science:<ul style="list-style-type: none">(i) temperature scales(ii) thermal expansion of materials(iii) properties of metals

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 7: Temperature

UNIT 2: Bimetallic Thermometers

OPERATIONS	KNOWLEDGE
2. Calibrating bimetallic thermometers	<ul style="list-style-type: none">(a) Interpretation of manufacturer's specifications to determine:<ul style="list-style-type: none">(i) temperature range(ii) accuracy and linearity(iii) type of calibration(b) Type, purpose and application of constant temperature mediums:<ul style="list-style-type: none">(i) oil baths(ii) salt baths(iii) metal blocks(c) Procedures for calibration of bimetallic thermometers(d) Methods of ensuring good thermal contact(e) Type, function and use of standards and test instruments(f) Techniques of zero and span adjustment(g) Methods of testing thermometers for speed of response and time constant(h) Mathematics -<ul style="list-style-type: none">conversion temperature scales(i) Science:<ul style="list-style-type: none">(i) thermal expansion(ii) thermal conductivity

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 7: Temperature

UNIT 2: Bimetallic Thermometers

OPERATIONS	KNOWLEDGE
<hr/>	
3. Maintaining and servicing bimetallic	<ul style="list-style-type: none">(a) Interpretation of manufacturer's service manuals(b) Service conditions(c) Methods of checking thermometers for correct operation(d) Procedures for replacing thermometers in thermowells(e) Type, care, application and handling of solvents(f) Techniques of cleaning thermowells(g) Methods of cleaning thermometers:<ul style="list-style-type: none">(i) mechanical(ii) ultrasonic(iii) chemical(h) Techniques of replacing components in the bimetallic thermometer:<ul style="list-style-type: none">(i) glass(ii) pointer(iii) mechanisms(i) Methods of underrange and overrange protection(j) Importance of checking thermometers for correct function(k) Science:<ul style="list-style-type: none">(i) organic and inorganic solvents(ii) vibration(iii) gears, mechanisms and linkages

BLOCK 7: Temperature

UNIT 3: Filled System Thermometers

OPERATIONS	KNOWLEDGE
1. Installing filled system thermometers	<ul style="list-style-type: none"> (a) Interpretation of drawings to determine: <ul style="list-style-type: none"> (i) type, material and location of the well (ii) type, size and position of the bulb (iii) type, mounting and location of the meter (iv) type, size and run of the capillary (b) Type, principle of operation and application of filled systems: <ul style="list-style-type: none"> (i) liquid filled (ii) vapour filled (iii) gas filled (iv) mercury filled (c) Type and application of sensing elements: <ul style="list-style-type: none"> (i) spiral, helical, capillary (ii) averaging (iii) tube (d) Type, function and application of measuring elements: <ul style="list-style-type: none"> (i) bourdon tube (ii) spiral (iii) helical (iv) bellows (e) Techniques of installing thermowells (f) Methods of shielding against direct radiation (g) Procedures in installation of bulbs in thermowells (h) Procedures and care when running capillaries (i) Type of protective armour and mounting (j) Type, function and application of measuring instruments: <ul style="list-style-type: none"> (i) indicating T.I. (ii) recording T.R. (k) Techniques of installation of measuring elements in instruments and connection to linkages

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 7: Temperature

UNIT 3: Filled System Thermometers

OPERATIONS	KNOWLEDGE
1. Installing filled system thermometers (cont'd)	<ul style="list-style-type: none">(l) Type, function and application of linkage mechanism(m) Methods of overrange and underrange protection(n) Type and method of mounting glands, rings, couplings, etc.(o) Importance of checking system for correct operation(p) Mathematics:<ul style="list-style-type: none">linear measurement for installation(q) Science:<ul style="list-style-type: none">(i) Boyles and Charles laws(ii) partial pressure(iii) heat transfer and thermal lags(iv) differential expansion

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 7: Temperature

UNIT 3: Filled System Thermometers

OPERATIONS

KNOWLEDGE

2. Calibrating filled system thermometers

- (a) Interpretation of manufacturer's specifications to determine:
 - (i) type of thermometer
 - (ii) temperature range
 - (iii) accuracy, linearity
 - (iv) type of compensation
- (b) Methods and types of calibration:
 - (i) field
 - (ii) shop
- (c) Considerations regarding ambient conditions
- (d) Type and use of standard test equipment:
 - (i) temperature bath
 - (ii) standard or reference thermometer
- (e) Methods of checking thermometer for correct operation
- (f) Techniques of calibration to preserve accuracy by taking into consideration:
 - (i) proper depth of immersion
 - (ii) time constant of thermometer
 - (iii) compensations
 - (iv) elevation of the bulb with respect to the measuring element
 - (v) barometric reading
- (g) Methods and types of compensation:
 - (i) case
 - (ii) transmission line
 - (iii) total
- (h) Techniques of adjusting positions of measuring elements and linkages in instruments for proper calibration
- (i) Methods of zero and range and angularity adjustment
- (j) Procedures in correction of errors caused by
 - (i) gravity, position
 - (ii) direct radiation
- (k) Mathematics:
 - (i) conversion of temperature scales
 - (ii) plotting graph
- (l) Science:
 - (i) differential expansion
 - (ii) thermal conductivity
 - (iii) Boyles and Charles Laws

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 7: Temperature

UNIT 3: Filled System Thermometers

OPERATIONS	KNOWLEDGE
<hr/>	
3. Maintaining and servicing filled system thermometers	<ul style="list-style-type: none">(a) Interpretation of service manuals to determine and check for:<ul style="list-style-type: none">(i) correct position and location of the bulb(ii) type of filled system(b) Methods for inspection and cleaning of:<ul style="list-style-type: none">(i) sensing elements(ii) measuring elements(iii) capillaries(c) Type, care and application of cleaning agents(d) Techniques of inspection for and effect of leaks in the filled system(e) Methods of testing filled system thermometers for correct operation(f) Care and use of portable test equipment(g) Procedures for replacement or refilling of defective filled systems in thermometers(h) Type and characteristic of fill mediums(i) Type, purpose and use of refilling equipment(j) Methods of sealing and testing for leaks(k) Techniques and importance of correct realignment or replacement of linkages and components(l) Mathematics:<ul style="list-style-type: none">(i) linear measurements(ii) geometrical ratios and angles(m) Science:<ul style="list-style-type: none">(i) organic solvents(ii) linkages and mechanisms(iii) gas laws(iv) vapour pressure

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 7: Temperature

UNIT 4: Pyrometry

OPERATIONS	KNOWLEDGE
<hr/>	
1. Fabricating and assembling thermocouples	<ul style="list-style-type: none">(a) Interpretation of drawings to determine:<ul style="list-style-type: none">(i) type and size of thermocouples(ii) material(iii) assembling instructions(iv) type of connectors(b) Type, purpose and function of thermocouples(c) Characteristics and application of thermocouple materials:<ul style="list-style-type: none">(i) iron - Constantan(ii) chromel - Alumel(iii) copper - Constantan(iv) platinum - (Platinum-Rhodium)(v) others(d) Methods of fabricating thermocouples(e) Techniques of welding, brazing and soldering(f) Procedures of making thermocouple junctions(g) Characteristics and uses of thermocouple insulators and insulator materials(h) Type, function and application of thermocouple fittings:<ul style="list-style-type: none">(i) bayonet(ii) spring loaded(iii) clamp(iv) washer(i) Techniques of assembling thermocouples and connection to terminals(j) Importance of proper selection of material for terminals and extension wires(k) Effect of junction e.m.f. on operation(l) Type, function and use of test equipment:<ul style="list-style-type: none">(i) ohmmeter(ii) megger(iii) magnifying glass(m) Procedures of testing thermocouple assemblies for continuity, insulations and shape(n) Type, purpose and application of shielding

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 7: Temperature

UNIT 4: Pyrometry

OPERATIONS	KNOWLEDGE
<hr/>	
1. Fabricating and assembling thermocouples (cont'd)	(o) Effect of stray signals on thermocouple output (p) Mathematics: (i) linear measurement for layout and dimensions (ii) temperature scales (q) Science: (i) thermal e.m.f. (ii) law of the intermediate metal (iii) ammeter - voltmeter - ohmmeter (iv) heat conduction and thermal conductivity (v) solders and fluxes

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 7: Temperature

UNIT 4: Pyrometry

OPERATIONS	KNOWLEDGE
<hr/>	
2. Calibrating thermocouples	<ul style="list-style-type: none">(a) Interpretation of manufacturer's specification to determine:<ul style="list-style-type: none">(i) type and purpose of thermocouple(ii) range(iii) accuracy, scale(iv) mounting, location(v) type of calibration(b) Type, function and use of test and calibration equipment:<ul style="list-style-type: none">(i) portable potentiometer(ii) portable bridge(iii) standard resistance thermometer(iv) standard thermocouple(v) constant temperature medium(vi) other(c) Type, purpose and application of constant temperature mediums:<ul style="list-style-type: none">(i) oil baths(ii) salt and molten metal baths(iii) metal blocks(d) Procedures for immersion of thermocouples for calibration(e) Effect and importance of correct immersion(f) Procedures in connecting thermocouples to potentiometers and test equipment(g) Importance of correct connection(h) Effect of junction e.m.f.'s on calibration(i) Procedures and equipment to ensure uniform cold junction temperature(j) Methods and components in cold junction compensation(k) Importance of accuracy in determining ambient temperature(l) Techniques to determine time constant and speed of response of thermocouples(m) Type of "Burn-out" protection(n) Procedures in compensating for "Burn-out" features in instruments when calibrating thermocouples or instruments(o) Techniques of plotting calibration curves

. MEASUREMENT .

BLOCK 7: Temperature

UNIT 4: Pyrometry

OPERATIONS	KNOWLEDGE
2. Calibrating thermocouples (cont'd)	(p) Mathematics: (i) conversion to temperature scale (ii) calculations to convert e.m.f. to temperature (iii) interpolation (q) Science: (i) temperature - EMF relationship (ii) Peltier, Thomson and Seebeck effects (iii) law of intermediate metal (iv) thermal conductivity (v) potentiometers and bridges (vi) Ohm's law

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 7: Temperature

UNIT 4: Pyrometry

OPERATIONS

KNOWLEDGE

3. Installing thermocouples

- (a) Interpretation of drawings to determine:
 - (i) type of thermocouple
 - (ii) type and location of thermowell
 - (iii) type of connectors
 - (iv) type, size and run of extension wires
 - (v) type of instrument to be connected
- (b) Service conditions:
 - (i) medium, chemical composition
 - (ii) pressure, temperature
 - (iii) vibration
- (c) Type, function and application of protective devices:
 - (i) tubes
 - (ii) wells
 - (iii) shields
- (d) Methods of installing protective devices
- (e) Techniques, materials and equipment used in:
 - (i) welding
 - (ii) soldering
 - (iii) brazing
- (f) Type and application of thermocouple and thermowell fittings and connectors
- (g) Methods of installing thermocouples in protective devices
- (h) Importance of good thermal contact between thermocouple and thermowell
- (i) Type, function and application of thermoconducting materials:
 - (i) pastes
 - (ii) foils
 - (iii) others
- (j) Procedures for connecting thermocouples to terminal blocks
- (k) Type and application of extension wires
- (l) Methods of installing extension wires
- (m) Importance and effect of shielding
- (n) Type, function and use of test equipment:
 - (i) ohmmeter
 - (ii) megger
 - (iii) portable potentiometer

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 7: Temperature

UNIT 4: Pyrometry

OPERATIONS	KNOWLEDGE
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3. Installing thermocouples (cont'd)	(o) Method and importance of checking thermocouples and extension wires for: (i) insulation (ii) grounds (iii) continuity (p) Mathematics: (i) linear measurements for installation (ii) ratios, powers, roots (q) Science: (i) thermal E.M.F. (ii) ammeter - voltmeter - ohmmeter (iii) thermal conductivity (iv) conductors and insulators (v) Ohm's law (vi) solders and fluxes

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 7: Temperature

UNIT 4: Pyrometry

OPERATIONS	KNOWLEDGE
<hr/>	
4. Maintaining and servicing thermocouples	<ul style="list-style-type: none">(a) Interpretation of service manuals to determine:<ul style="list-style-type: none">(i) type and function of thermocouples(ii) type and function of thermocouple connectors(iii) type and size of thermowells(iv) recommended procedures to clean thermocouples and thermowells(b) Service considerations(c) Type and function of solvents and cleaning fluids(d) Techniques of cleaning thermocouples and thermowells(e) Importance of adequate ventilation and fire protection when handling solvents(f) Type, function and application of thermocouple components:<ul style="list-style-type: none">(i) thermocouples(ii) connectors and fittings(iii) extension wires(iv) junctions(v) terminal boxes and switches(g) Methods of replacement and repair of thermocouple components(h) Techniques in running wiring harnesses and connecting to terminals(i) Techniques and equipment to solder or braze thermocouple components(j) Type and function of test equipment:<ul style="list-style-type: none">(i) multimeter(ii) portable potentiometer(iii) megger(k) Procedures for testing wiring and thermocouples for continuity and insulation(l) Importance of checking thermocouple installation for correct operation(m) Mathematics:<ul style="list-style-type: none">(i) linear measurements for layout and assembly(ii) powers, roots, ratios

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 7: Temperature

UNIT 4: Pyrometry

OPERATIONS

KNOWLEDGE

4. Maintaining and servicing
thermocouples (cont'd)

(n) Science:

- (i) thermal E.M.F.
- (ii) ammeter - voltmeter - ohmmeter
- (iii) thermal conductivity
- (iv) Ohm's law
- (v) potentiometer
- (vi) organic solvents
- (vii) fluxes

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 7: Temperature

UNIT 4: Pyrometry

OPERATIONS

KNOWLEDGE

5. Installing and aligning radiation and optical type pyrometers

- (a) Interpretation of drawings and manufacturer's specifications to determine:
 - (i) type and application of pyrometer
 - (ii) location
 - (iii) type of mounting
 - (iv) recommended procedures for alignment
- (b) Type and application of radiation pyrometers:
 - (i) lens type
 - (ii) mirror type
- (c) Type and application of optical pyrometers:
 - (i) variable lamp current
 - (ii) variable target intensity and standard light source
- (d) Techniques of installing radiation and optical pyrometers
- (e) Importance of care while handling radiation pyrometers
- (f) Type, method and importance of providing correct power supply
- (g) Type of radiation pyrometer head cooling:
 - (i) air
 - (ii) liquid
- (h) Type of temperature indication:
 - (i) manual balance type
 - (ii) automatic balance type
- (i) Methods to provide adequate cooling for radiation pyrometers
- (j) Techniques and equipment to wire and connect pyrometer heads to indicators
- (k) Techniques, material and equipment to solder, braze or connect pyrometer wire and components
- (l) Procedures for checking pyrometer installation for correct function and operation
- (m) Mathematics:
 - (i) linear and angular measurements for installation
 - (ii) temperature scales and conversions
 - (iii) roots and powers

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 7: Temperature

UNIT 4: Pyrometry

OPERATIONS	KNOWLEDGE
<hr/>	
5. Installing and aligning radiation and optical type pyrometers (cont'd)	(n) Science: <ul style="list-style-type: none">(i) principle of radiation thermometry(ii) ammeter - voltmeter - ohmmeter(iii) spectral emissivity(iv) heat transfer(v) lenses and mirrors(vi) black body conditions

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 7: Temperature

UNIT 4: Pyrometry

OPERATIONS

KNOWLEDGE

6. Maintaining and servicing radiation and optical type pyrometers

- (a) Interpretation of service manuals and manufacturer's specification to determine:
 - (i) type, function and use of instrument
 - (ii) temperature range
 - (iii) response
 - (iv) recommended procedures for checking calibration of pyrometers
 - (v) suggested procedures to service, clean, replace or repair pyrometer components
- (b) Service considerations
- (c) Type, function and application of radiation type pyrometer components:
 - (i) vacuum thermocouple detector
 - (ii) thermopile detector
 - (iii) thermistor type detector
 - (iv) bolometer type detector
 - (v) phototube type detector
 - (vi) lenses
 - (vii) open and sighting tubes
 - (viii) closed end sighting tubes
- (d) Methods and equipment to test, service replace or repair radiation pyrometer components
- (e) Type, function and application of optical pyrometer components:
 - (i) lenses
 - (ii) filters
 - (iii) standard light sources
 - (iv) screens
- (f) Methods and equipment to test, service replace or repair optical pyrometer components
- (g) Procedures and equipment to check calibration of radiation and optical pyrometers

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 7: Temperature

UNIT 4: Pyrometry

OPERATIONS	KNOWLEDGE
<hr/>	
6. Maintaining and servicing radiation and optical type pyrometers (cont'd)	<ul style="list-style-type: none">(h) Methods of compensation in radiation pyrometry for or effect of:<ul style="list-style-type: none">(i) reference junction temperature(ii) size of target area(iii) absorbing medium(iv) total emissivity(v) vibration(i) Methods of compensation in optical pyrometry for or effect of:<ul style="list-style-type: none">(i) aging(ii) high temperature(iii) voltage supply(iv) size of target(v) distance from target(vi) absorbing media(vii) spectral emissivity(viii) response(j) Procedures in cleaning optical and radiation pyrometer components(k) Type and care in handling solvents(l) Importance of checking pyrometers for correct function and operation(m) Mathematics:<ul style="list-style-type: none">(i) linear and angular measurements for layout and assembly(ii) plane and solid angles for alignment(iii) temperature scales and conversions(iv) roots, powers, ratios(n) Science:<ul style="list-style-type: none">(i) principle of radiation(ii) Stefan-Boltzman law(iii) black body conditions(iv) frequency spectrum(v) energy absorption(vi) spectral emissivity(vii) Ohm's law(viii) ammeter - voltmeter - ohmmeter(ix) organic solvents(x) solders(xi) fluxes

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 7: Temperature

UNIT 5: Resistance Thermometry

OPERATIONS

KNOWLEDGE

1. Installing resistance type sensing elements

- (a) Interpretation of drawings to determine:
 - (i) type, size and temperature range of element
 - (ii) type and size of thermowell
 - (iii) location
 - (iv) instrument to be connected
- (b) Type, purpose, function and use of sensing elements:
 - (i) resistance bulbs
 - (ii) bonded wire elements
 - (iii) thermistor probes
- (c) Materials used for resistive elements:
 - (i) platinum
 - (ii) nickel
 - (iii) copper
 - (iv) carbon
 - (v) semiconductors
- (d) Type, purpose and application of fittings:
 - (i) bayonets
 - (ii) springloaded, glands
 - (iii) clamps
 - (iv) bare elements cemented in
 - (v) slip-rings and brushes
- (e) Service considerations:
 - (i) type of medium
 - (ii) temperature and pressure
 - (iii) corrosive atmosphere
- (f) Methods of protecting sensing elements with:
 - (i) tubes
 - (ii) walls
 - (iii) shields
- (g) Type, function and method of mounting thermowells
- (h) Techniques in installation of sensing elements in protective devices
- (i) Types and methods of application of thermoconductive materials:
 - (i) pastes
 - (ii) foils
 - (iii) liquids
- (j) Methods of wiring compensating resistances in the connecting heads

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 7: Temperature

UNIT 5: Resistance Thermometry

OPERATIONS	KNOWLEDGE
<hr/>	
1. Installing resistance type sensing elements (cont'd)	<ul style="list-style-type: none">(k) Type of distance compensation:<ul style="list-style-type: none">(i) two wire(ii) three wire(iii) four wire(l) Methods of compensation for:<ul style="list-style-type: none">(i) positive error(ii) negative error(iii) linearity(m) Methods of connecting element to sensing circuits(n) Type, function and application of measuring circuits:<ul style="list-style-type: none">(i) ohmmeter(ii) wheatstone or other bridges(iii) self-balancing servo-operated system(o) Procedures for connecting extension wires(p) Methods of shielding(q) Procedures and importance of testing extension wires for continuity(r) Importance of testing installation for correct operation(s) Mathematics:<ul style="list-style-type: none">linear measurements for installation and layout(t) Science:<ul style="list-style-type: none">(i) Ohm's law(ii) thermal conductivity(iii) ammeter - voltmeter - ohmmeter(iv) potentiometer and bridges

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 7: Temperature

UNIT 5: Resistance Thermometry

OPERATIONS

KNOWLEDGE

2. Calibrating resistance type sensing elements

- (a) Interpretation of manufacturer's specifications to determine:
 - (i) temperature - resistance relationship
 - (ii) temperature range
 - (iii) accuracy and linearity
- (b) Service considerations:
 - (i) medium (composition)
 - (ii) pressure
 - (iii) temperature
- (c) Type of coefficients of resistivity:
 - (i) positive
 - (ii) negative
 - (iii) exponential
- (d) Methods of connecting resistive sensing element to the test equipment
- (e) Effect of electric current on the element on self heating and calibration
- (f) Type, purpose and application of calibration test equipment and standard:
 - (i) standard resistance bulb
 - (ii) potentiometers
 - (iii) bridges
 - (iv) temperature bath
- (g) Methods of calibration:
 - (i) shop
 - (ii) field
- (h) Techniques and importance of care during relative calibration
- (i) Methods of connecting trimming and compensating resistors in the connecting heads
- (j) Type, purpose and application of distance compensation:
 - (i) 2 wire system
 - (ii) 3 wire system
 - (iii) 4 wire system
- (k) Methods of connecting resistive sensing elements to measuring circuits in instruments
- (l) Mathematics:
 - (i) temperature scales
 - (ii) graphs
 - (iii) roots and powers
 - (iv) exponential functions

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 7: Temperature

UNIT 5: Resistance Thermometry

OPERATIONS	KNOWLEDGE
<hr/>	
2. Calibrating resistance type sensing elements (cont'd)	(m) Science: (i) Ohm's Law (ii) wheatstone bridge and potentiometer (iii) heat transfer, thermal conductivity

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 7: Temperature

UNIT 5: Resistance Thermometry

OPERATIONS	KNOWLEDGE
<hr/>	
3. Maintaining and servicing resistive sensing elements	<ul style="list-style-type: none">(a) Interpretation of service manuals(b) Methods of checking resistance thermometers for correct operation(c) Type and use of field test equipment:<ul style="list-style-type: none">(i) wheatstone bridge(ii) ohmmeter(d) Procedures for cleaning and inspection of thermal elements(e) Techniques of cleaning thermowells and bulbs:<ul style="list-style-type: none">(i) mechanical(ii) chemical(iii) ultrasonic(f) Procedures for replacing and supporting thermowells(g) Methods of replacing resistance sensing elements(h) Importance of correct connection, compensation and calibration(i) Mathematics:<ul style="list-style-type: none">(i) ratios and roots for calibration(ii) graphs for checking calibration(iii) temperature conversion(j) Science:<ul style="list-style-type: none">(i) organic solvents(ii) Ohm's Law(iii) bridges and potentiometers(iv) ammeter - voltmeter - ohmmeter

BLOCK 8: Pressure

TABLE OF CONTENTS

UNIT 1: Manometers (Liquid Column)	Page 105
2: Bellows and Diaphragm Gauges	109
3: Bourdon Spring Gauges	114
4: Vacuum Gauges	120
5: Electrical Transducers	123
6: Pressure Regulators	127

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 8: Pressure

UNIT 1: Manometers (Liquid Column)

OPERATIONS

KNOWLEDGE

1. Selecting Manometers

- (a) Type, purpose and characteristics of manometers
- (b) Service conditions:
 - (i) operating pressures, normal, maximum and minimum
 - (ii) operating temperatures, normal maximum and minimum
 - (iii) physical and chemical properties of process fluid
- (c) Type of manometers and their characteristics:
 - (i) U tube
 - (ii) well type, vertical
 - (iii) well type, inclined
 - (iv) differential pressure
 - (v) absolute pressure
- (d) Type and use of manometer liquids:
 - (i) mercury
 - (ii) hydrocarbon
 - (iii) others
- (e) Characteristics of manometer liquids:
 - (i) specific gravity
 - (ii) chemical properties
- (f) Use of corrosion resistant materials
- (g) Type and size of glass tubing, pressure and temperature ratings
- (h) Type or glands and gland packings
- (i) Type of over-pressure traps
- (j) Type of seals:
 - (i) liquid
 - (ii) air
 - (iii) volumetric
- (k) Type of pulsation dampeners
- (l) Methods of providing electrical alarm contacts
- (m) Type of scales, accuracy required
- (n) Interpretation of manufacturer's literature

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 8: Pressure

UNIT 1: Manometers (Liquid Column)

OPERATIONS	KNOWLEDGE
<hr/>	
2. Calibrating Manometers	<ul style="list-style-type: none">(a) Service conditions(b) Accuracy required(c) Use of test equipment(d) Methods of connecting test equipment(e) Methods of applying test pressure(f) Importance of avoiding leaks and methods of detection(g) Correct method of reading height of liquid column(h) Interpretation of vernier scales(i) Methods of setting zero(j) Importance of correct slope of inclined manometers(k) Type of manometer fluids, properties, uses, limitations(l) Methods of checking specific gravity of manometer fluids(m) Importance of care when handling mercury(n) Avoidance of errors due to:<ul style="list-style-type: none">(i) temperature(ii) gravity(iii) scale(iv) capillary effects(v) compressibility(vi) absorbed gases(o) Mathematics:<ul style="list-style-type: none">(i) converting pressure scales(ii) calculating temperature and gravity corrections(p) Science:<ul style="list-style-type: none">(i) density, specific gravity(ii) temperature coefficients of expansion(iii) Pascal's principle(iv) units of weight and measure

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION

. MEASUREMENT .

BLOCK 8: Pressure

UNIT 1: Manometer (Liquid Column)

OPERATIONS	KNOWLEDGE
<hr/>	
3. Installing manometers	<ul style="list-style-type: none">(a) Interpretation of drawings to determine:<ul style="list-style-type: none">(i) purpose of installation(ii) service conditions(iii) location(iv) method of mounting(v) method of connecting(b) Methods of drilling holes in metal, wood and concrete(c) Type of fasteners(d) Importance of correct level, use of spirit level, protractor(e) Type of gland packing(f) Correct procedure for packing and tightening glands(g) Type of manometer fluids, uses, limitations, properties(h) Methods of draining, cleaning and filling manometers(i) Type and size of connecting piping and tubing(j) Methods of cutting, bending, threading and fitting piping and tubing(k) Type of fittings and connectors(l) Type of valves(m) Methods of assembly and mounting of 3 - valve manifolds(n) Use of thread compounds(o) Methods of testing for leaks(p) Correct slope of connecting lines(q) Location of drain valves, catchpots, vent valves(r) Use of pulsation dampeners(s) Use of seal pots(t) Use of over-pressure traps

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 8: Pressure

UNIT 1: Manometers (Liquid Column)

OPERATIONS	KNOWLEDGE
<hr/>	
4. Maintaining and repairing manometers	<ul style="list-style-type: none">(a) Service conditions(b) Type of manometer liquids, properties uses, limitations(c) Toxic properties of manometer liquids(d) Methods of disconnecting manometers and equalizing differential pressures(e) Methods of draining, cleaning, refilling(f) Importance of keeping connecting lines clear and free of leaks(g) Methods of checking slope of inclined manometers, use of spirit level, protractor(h) Type and size of glass tubing used(i) Methods of removing, handling and disposing of broken tubing(j) Methods of cutting, bending, annealing and fire-polishing glass tubing(k) Methods of cleaning glass tubing(l) Type of gland packing used(m) Methods of repacking glands and tightening gland nuts(n) Type of shut-off and equalizing valves used(o) Type of valve packing(p) Methods of repacking valves(q) Methods of checking for leaks(r) Importance of using clean manometer liquids(s) Methods of cleaning mercury

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 8: Pressure

UNIT 2: Bellows and Diaphragm Gauges

OPERATIONS	KNOWLEDGE
<hr/>	
1. Selecting bellows and diaphragm gauges	<ul style="list-style-type: none">(a) Type, purpose and characteristics of gauges(b) Service conditions:<ul style="list-style-type: none">(i) minimum, maximum and normal operating pressures(ii) operating temperatures(iii) physical and chemical properties of process fluid(iv) effects of dust, fume, spray, shock, vibration and methods of protection(c) Type of gauges and uses:<ul style="list-style-type: none">(i) non-metallic diaphragm(ii) metallic diaphragm(iii) bellows(d) Type of gauge castings and uses:<ul style="list-style-type: none">(i) direct connection(ii) front-of-panel mounting(iii) flush panel mounting(e) Type of gauge casing materials, their properties and uses:<ul style="list-style-type: none">(i) cast iron(ii) phenol(iii) bronze and other alloys(f) Type and size of dials(g) Dial graduations required(h) Type of diaphragm and bellows materials and their characteristics(i) Characteristics of bellows elements:<ul style="list-style-type: none">(i) size and type(ii) spring rate(iii) maximum stroke(iv) maximum working pressure(j) Type of movements, their characteristics and applications(k) Methods of sealing casings and front covers(l) Type of gaskets and retaining rings for front cover and methods of attachment(m) Type of sockets and connectors(n) Type and size of threaded connections

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 8: Pressure

UNIT 2: Bellows and Diaphragm Gauges

OPERATIONS	KNOWLEDGE
1. Selecting bellows and diaphragm gauges (cont'd)	(o) Type and use of pulsation dampeners: (i) hydraulic seal (ii) moving pin (iii) needle valve (iv) throttle screw (v) porous metal filter (p) Type and use of gauge valves and cocks (q) Type of seals for corrosive fluids, materials, methods of construction (r) Type of electrical alarm contacts (s) Interpretation of manufacturer's literature

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 8: Pressure

UNIT 2: Bellows and Diaphragm Gauges

OPERATIONS	KNOWLEDGE
<hr/>	
2. Installing bellows and diaphragm type gauges	<ul style="list-style-type: none">(a) Interpretation of drawings to determine:<ul style="list-style-type: none">(i) purpose of installation(ii) service conditions(iii) location(iv) method of mounting and connecting(b) Interpretation of manufacturer's instruction manuals to determine type and location of gauge(c) Methods of mounting(d) Methods of drilling and cutting metal panels, use of power tools(e) Type of fasteners(f) Type and size of connecting tubing and piping(g) Methods of cutting, bending, threading and fitting piping and tubing(h) Type of fittings and connectors(i) Methods of mounting connecting piping and tubing(j) Correct slope of connecting lines(k) Methods of providing means of cleaning and blowing down lines(l) Use of drain valves, vent valves, catchpots(m) Type and use of seals:<ul style="list-style-type: none">(i) liquid(ii) air(iii) volumetric(n) Type of pulsation dampeners(o) Methods of checking for leaks(p) Effects of mechanical vibration and methods of protection

. MEASUREMENT .

BLOCK 8: Pressure

UNIT 2: Bellows and Diaphragm Gauges

OPERATIONS	KNOWLEDGE
3. Calibrating bellows and diaphragm type gauges	<ul style="list-style-type: none"> (a) Range of operating pressures (b) Operating temperature (c) Accuracy required (d) Type of gauges (e) Interpretation of manufacturer's instruction bulletins and drawings (f) Type of test equipment and uses: <ul style="list-style-type: none"> (i) dead weight tester (ii) precision manometer (iii) secondary standard gauges (g) Methods of connecting gauge to test equipment (h) Methods of applying test pressure (i) Explosive properties of oxygen-oil mixtures (j) Methods of cleaning oxygen gauges and avoiding contamination with mineral oils (k) Type of hydraulic fluids used for testing: <ul style="list-style-type: none"> (i) oxygen gauges (ii) others (l) Methods of removing pointer and cover (m) Methods of setting zero (n) Methods of making range adjustment (o) Effect of range adjustment on zero setting (p) Methods of avoiding errors due to: <ul style="list-style-type: none"> (i) hysteresis (ii) parallax (iii) capillary effects (q) Effect of high temperatures at gauge location on calibration, interpretation of temperature correction graphs and tables (r) Mathematics: - converting of pressure scales (s) Science: <ul style="list-style-type: none"> (i) mechanics, gears, levers (ii) Pascal's principle (iii) Boyles Law (iv) Charles Law

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 8: Pressure

UNIT 2: Bellows and Diaphragm Gauges

OPERATIONS	KNOWLEDGE
<hr/>	
4. Maintaining and repairing bellows and diaphragm gauges	<ul style="list-style-type: none">(a) Service conditions(b) Type of gauges:<ul style="list-style-type: none">(i) non-metallic diaphragm(ii) metallic diaphragm(iii) metallic bellows(c) Interpretation of manufacturer's instruction manuals(d) Methods of cleaning(e) Methods of avoiding damage to delicate linkages(f) Effects of wear and corrosion(g) Effects of leaks in diaphragm or bellows(h) Methods of checking connecting lines for blockage or leakage(i) Methods of blowing down and clearing connecting lines(j) Adjustment of zero setting(k) Procedure for putting gauges back in service(l) Importance of avoiding excessive differential pressures when putting gauge in service

. MEASUREMENT .

BLOCK 8: Pressure

UNIT 3: Bourdon Spring Gauges

OPERATIONS	KNOWLEDGE
1. Selecting bourdon spring type pressure gauges	<ul style="list-style-type: none"> (a) Type, purpose and characteristics of bourdon spring type pressure gauges (b) Service conditions: <ul style="list-style-type: none"> (i) minimum, maximum and normal operating pressures (ii) physical and chemical properties of process fluid (c) Application and uses of gauges: <ul style="list-style-type: none"> (i) pressure (ii) vacuum (iii) compound (iv) duplex (v) differential (vi) refrigeration (vii) ammonia (viii) oxygen (ix) Christmas tree (x) reid vapour test (xi) carbonation test (d) Type of gauge casings: <ul style="list-style-type: none"> (i) direct connection (ii) front of panel mounting (iii) flush panel mounting (e) Gauge casing materials: <ul style="list-style-type: none"> (i) cast iron (ii) phenol (iii) brass and other alloys (f) Dial sizes (g) Dial graduations (h) Type of Bourdon springs: <ul style="list-style-type: none"> (i) C-tube (ii) spiral (iii) helical (i) Bourdon spring materials: <ul style="list-style-type: none"> (i) phosphor bronze (ii) alloy steel (iii) monel (iv) stainless steel (v) beryllium copper (j) Service applications for various bourdon spring materials (k) Pressure ranges for various bourdon tube materials

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 8: Pressure

UNIT 3: Bourdon Spring Gauges

OPERATIONS	KNOWLEDGE
<hr/>	
1. Selecting bourdon spring type pressure gauges (cont'd)	(l) Type of movements: (i) gear and pinion (ii) helical gear (m) Movement materials (n) Type of gaskets for front covers (o) Type of retaining rings for front covers and methods of attachment (p) Use of blow-out discs, safety glass and plastic covers, solid front casings (q) Type of sockets and socket materials (r) Type and size of threaded connections (s) Type and use of pulsation dampeners: (i) hydraulic seal (ii) moving pin (iii) needle valve (iv) throttle screws (v) porous metal filter (t) Type of gauge valve and cocks (u) Use of siphons: (i) coil type (ii) pigtail (v) Type of seals for corrosive fluids, materials, methods of construction (w) Type of electrical alarm contacts (x) Interpretation of manufacturer's literature

. MEASUREMENT .

BLOCK 8: Pressure

UNIT 3: Bourdon Spring Gauges

OPERATIONS	KNOWLEDGE
2. Calibrating bourdon spring type gauges	<ul style="list-style-type: none"> (a) Range of operating pressures (b) Accuracy required (c) Methods of cleaning bourdon spring (d) Methods of cleaning movement (e) Solvents used for cleaning (f) Toxic properties of solvents and methods of providing adequate ventilation (g) Selection of suitable test equipment: <ul style="list-style-type: none"> (i) dead weight tester (ii) precision manometer (iii) secondary standard gauge (h) Methods of connecting to test equipment (i) Methods of avoiding strain on gauge casing (j) Explosive properties of oxygen-oil mixtures (k) Methods of cleaning oxygen gauges and avoiding contamination with mineral oils (l) Type of hydraulic fluids for testing: <ul style="list-style-type: none"> (i) oxygen gauges (ii) others (m) Methods of applying test pressure (n) Correct procedures for operating dead weight tester (o) Methods of removing gauge face cover (p) Methods of removing pointer from pinion shaft, use of pointer jack (q) Methods of avoiding errors due to: <ul style="list-style-type: none"> (i) hysteresis (ii) parallax (iii) capillary effects (r) Methods of setting zero (s) Methods of making range adjustments (t) Effect of range adjustment on zero setting (u) Effect of high temperatures at gauge location on calibration, interpretation of temperature correction graphs and tables (v) Effect of water leg on calibration, methods of corrections

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 8: Pressure

UNIT 3: Bourdon Spring Gauges

OPERATIONS

KNOWLEDGE

2. Calibrating bourdon spring
type gauges (cont'd)

(w) Mathematics:

(i) converting of pressure scales

(ii) calculation of correction factors

(x) Science:

(i) Pascal's principle

(ii) mechanics, levers gears

(iii) Boyles Law

(iv) Charles Law

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 8: Pressure

UNIT 3: Bourdon Spring Gauges

OPERATIONS	KNOWLEDGE
<hr/>	
3. Installing bourdon spring type gauges	<ul style="list-style-type: none">(a) Interpretation of drawings to determine:<ul style="list-style-type: none">(i) purpose of installation(ii) service conditions(iii) location(iv) method of mounting and connecting(b) Type of gauges and uses(c) Type of connections:<ul style="list-style-type: none">(i) pipe thread(ii) straight thread and gasket(iii) flanged(d) Methods of tightening threaded connections(e) Use of thread compounds(f) Methods of avoiding strain on gauge casing(g) Methods of drilling and cutting instrument panels, use of hand and power tools(h) Type of fasteners(i) Type and size of connecting tubing and piping(j) Methods of cutting, bending, threading and fitting piping and tubing(k) Type of fittings and connectors(l) Methods of mounting connecting piping and tubing(m) Correct shape of connecting lines(n) Type of gauge valves and cocks; methods of installing(o) Type of pulsation dampeners and methods of installing(p) Methods of adjusting pulsation dampeners(q) Effects of mechanical vibration and methods of protection(r) Use of drain valves, catchpots, vent valves(s) Type and use of seals:<ul style="list-style-type: none">(i) liquid(ii) air(iii) volumetric(t) Methods of checking for leaks

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 8: Pressure

UNIT 3: Bourdon Spring Gauges

OPERATIONS

KNOWLEDGE

4. Maintaining and repairing
bourdon spring type gauges

- (a) Service conditions
- (b) Type of gauges
- (c) Interpretation of manufacturer's instruction manuals
- (d) Methods of cleaning bourdon tubes
- (e) Methods of cleaning linkage and gears
- (f) Procedures for checking for wear, corrosion, binding
- (g) Methods of replacement or repair of gears and linkages
- (h) Methods of adjusting hairspring
- (i) Procedures for removing and replacing front covers
- (j) Methods of removing and replacing pointers, use of pointer jack
- (k) Procedures for making sweated solder joints
- (l) Methods of soldering, using:
 - (i) lead-tin solder
 - (ii) silver solder
- (m) Methods, of brazing, care and use of torches, burners
- (n) Care and use of propane and oxygen cylinders
- (o) Methods of drilling and tapping holes

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 8: Pressure

UNIT 4: Vacuum Gauges

OPERATIONS	KNOWLEDGE
<hr/>	
1. Selecting vacuum gauge	(a) Type and characteristics of vacuum gauges (b) Operating range (c) Application and uses of vacuum gauges: (i) manometer (ii) diaphragm of bellows (iii) bourdon spring (iv) McLeod (v) thermal conductivity (Pirani and thermocouple) (vi) ionization (vii) special gauges (d) Interpretation of manufacturer's literature

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 8: Pressure

UNIT 4: Vacuum Gauges

OPERATIONS	KNOWLEDGE
<hr/>	
2. Repairing and calibrating vacuum gauges	<ul style="list-style-type: none">(a) Operational range of gauge(b) Accuracy required(c) Use of test equipment(d) Care and operation of vacuum pumps(e) Methods of connecting gauge and pump to test equipment(f) Type and size of vacuum tubing(g) Methods of connecting Pirani element and compensating element in Wheatstone bridge circuit(h) Methods of setting zero of Wheatstone bridge(i) Interpretation of current vs vacuum tables and graphs for Pirani and thermocouple gauges(j) Principle of thermocouple gauge(k) Methods of connecting thermocouple gauge to measuring circuit(l) Reading microammeters(m) Principles of ionization gauges:<ul style="list-style-type: none">(i) hot filament(ii) cold filament(n) Type of power supplies and measuring circuits for ionization gauges(o) Methods of wiring power supplies and measuring circuits for ionization gauges(p) Effect of barometric pressure and ambient temperature(q) Interpretation of manufacturer's instruction manuals(r) Interpretation of wiring diagrams(s) Care and use of electrical test equipment:<ul style="list-style-type: none">(i) portable potentiometer(ii) voltmeters, ammeters, ohmmeters(iii) tube tester(t) Procedures for locating and correcting electrical faults(u) Soldering and brazing methods(v) Type, size and use of soldering irons, guns and torches(w) Type of solder, brazing rods and fluxes

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 8: Pressure

UNIT 4: Vacuum Gauges

OPERATIONS	KNOWLEDGE
<hr/>	
2. Repairing and calibrating vacuum gauges (cont'd)	(x) Mathematics - conversion of pressure scales (y) Science: (i) molecular theory (ii) gas laws (iii) thermo-electric effects (iv) AC and DC electricity, bridge circuits (v) electronics

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 8: Pressure

UNIT 5: Electrical Transducers

OPERATIONS

KNOWLEDGE

1. Selecting electrical transducer type pressure gauges

- (a) Type, purpose and characteristics of transducer type pressure gauges
- (b) Service conditions:
 - (i) pressure and temperature range
 - (ii) physical and chemical properties of process fluid
 - (iii) frequency and amplitude of pulsating pressures
- (c) Characteristics and use of transducers:
 - (i) strain gauge
 - (ii) resistive
 - (iii) magnetic
 - (iv) capacitive
 - (v) piezoelectric
 - (vi) oscillometric
 - (vii) inductive
 - (viii) electromagnetic
 - (ix) electromechanical
- (d) Type of measuring circuits:
 - (i) bridge
 - (ii) potentiometer
 - (iii) amplifier
 - (iv) oscilloscope
- (e) Type and characteristics of sensing elements:
 - (i) bellows and diaphragm
 - (ii) bourdon spring
 - (iii) bellows and cantilever beam
 - (iv) ring type
 - (v) catenary diaphragm
- (f) Materials of construction of sensing elements and their characteristics
- (g) Indicating and recording methods
- (h) Mathematics -
 - conversion of pressure scales
- (i) Science:
 - (i) stress, strain, Young's modulus
 - (ii) AC and DC electricity, resistivity
 - (iii) electronic circuits, power supplies, oscillators, amplifiers, bridges circuits

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 8: Pressure

UNIT 5: Electrical Transducers

OPERATIONS	KNOWLEDGE
2. Calibrating electrical transducer type pressure gauges	<ul style="list-style-type: none"> (a) Interpretation of manufacturer's instruction manuals and wiring diagrams (b) Operational range of gauge (c) Accuracy required (d) Type and characteristics of electrical elements (e) Type and characteristics of electrical transducers (f) Type of measuring circuits (g) Type and use of test equipment: <ul style="list-style-type: none"> (i) manometers (ii) dead weight tester (iii) secondary standard gauges (h) Methods of connecting gauge to test equipment (i) Methods of connecting and wiring measuring circuits (j) Methods of applying test pressure (k) Methods of indicating pressures: <ul style="list-style-type: none"> (i) ammeters, voltmeters (ii) light spot galvanometer (iii) oscilloscope (l) Methods of recording pressures: <ul style="list-style-type: none"> (i) self balancing potentiometer (ii) oscillograph (iii) oscilloscope and camera (m) Effects of temperature (n) Methods of temperature compensation (o) Methods of setting zero (p) Procedures for adjusting range span (q) Methods of testing for: <ul style="list-style-type: none"> (i) linearity (ii) repeatability (iii) hysteresis (r) Mathematics: <ul style="list-style-type: none"> (i) conversion of pressure scales (ii) calculation of gauge factors (s) Science: <ul style="list-style-type: none"> (i) gas laws (ii) Pascal's principle (iii) Young's modulus (iv) resistivity, Ohm's law (v) basic AC and DC electricity (vi) bridge circuits (vii) electronics - theory of oscillators, amplifiers, self-balancing potentiometers, oscilloscopes

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 8: Pressure

UNIT 5: Electrical Transducers

OPERATIONS

KNOWLEDGE

3. Installing electrical transducer type pressure measuring instruments

- (a) Interpretation of drawings to determine:
 - (i) purpose of installation
 - (ii) service conditions
 - (iii) location
 - (iv) method of mounting and connecting
- (b) Interpretation of manufacturer's instruction manuals and wiring diagrams
- (c) Type of sensing elements
- (d) Type and capabilities of transducers
- (e) Type of measuring circuits
- (f) Methods of connecting transducer to process equipment
- (g) Methods of mounting measuring instruments
- (h) Use of hand and power tools for drilling and cutting metal panels
- (i) Procedures for electrical wiring
- (j) Wire gauges
- (k) Type of electrical insulation
- (l) Methods of electrostatic and electromagnetic shielding
- (m) Methods of recording:
 - (i) self balancing potentiometers
 - (ii) oscillographs
 - (iii) oscilloscope and camera

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 8: Pressure

UNIT 5: Electrical Transducers

OPERATIONS	KNOWLEDGE
<hr/>	
4. Repairing electrical transducer type pressure measuring instrument	<ul style="list-style-type: none">(a) Interpretation of manufacturer's instruction manuals and wiring diagrams(b) Service conditions(c) Type and characteristics of sensing elements(d) Type and characteristics of transducers(e) Details of measuring circuits(f) Methods of indicating and recording pressures(g) Care and use of test equipment:<ul style="list-style-type: none">(i) portable potentiometer(ii) ohmmeter(iii) vacuum tube voltmeter(iv) oscilloscope(v) tube tester(h) Methods of soldering and brazing(i) Type and size of soldering irons, guns and torches(j) Type of solder, brazing rods and fluxes(k) Procedures for locating and correcting electrical faults(l) Methods of making mechanical repairs to sensing element(m) Mathematics -<ul style="list-style-type: none">calculation of electrical quantities(n) Science:<ul style="list-style-type: none">(i) Young's modulus(ii) AC and DC electricity(iii) electronics

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 8: Pressure

UNIT 6: Pressure Regulators

OPERATIONS

KNOWLEDGE

1. Repairing and calibrating pressure regulators for gas cylinder service

- (a) Physical and chemical properties of various compressed gases commonly used in industry
- (b) Cylinder pressures used for these gases
- (c) Local and Government regulations regarding use, testing, storing and transporting gas cylinders
- (d) Type of regulators:
 - (i) single stage
 - (ii) two stage
 - (iii) high pressure
 - (iv) low pressure
 - (v) low pressure - high volume
 - (vi) vacuum
- (e) Materials of construction of regulators, their properties and uses
- (f) Type and size of diaphragms
- (g) Diaphragm materials, characteristics, properties, uses
- (h) Type of valve plugs and seats
- (i) Valve plug and seat materials, characteristics and uses
- (j) Spring sizes, rates, materials of construction
- (k) Cylinder pressure rating of regulator
- (l) Delivery pressure range of regulator
- (m) Maximum flow rate of regulator
- (n) Type, size and range of pressure gauges
- (o) Type of couplers and adapters used for connecting to cylinders and methods of attachment to regulator
- (p) Local regulations regarding use of couplers and adapters
- (q) Methods of dismantling and assembling regulators
- (r) Methods of repairing or replacing diaphragms
- (s) Procedures for re-seating valves and replacement of parts
- (t) Methods of adjusting spring tension

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 8: Pressure

UNIT 6: Pressure Regulators

OPERATIONS	KNOWLEDGE
<hr/>	
1. Repairing and calibrating pressure regulators for gas cylinder service (cont'd)	(u) Use of pressure testing equipment: (i) manometer (ii) dead weight tester (iii) secondary standard gauges (v) Methods of repairing, adjusting and calibrating pressure gauges (w) Type of regulator valves: (i) all-purpose (ii) check (iii) needle (iv) packless (v) safety relief (vi) toggle (x) Methods of repairing valves (y) Mathematics - conversion of pressure scales (z) Science: (i) gas laws (ii) Pascal's principle (iii) physics of liquefied gases, vapour pressure, boiling point

BLOCK 9: Level and Density

TABLE OF CONTENTS

UNIT 1: Visual Indicators	Page 130
2: Buoyancy Methods	134
3: Pressure Methods	138
4: Dielectric Methods	143
5: Gamma Ray Methods	147
6: Temperature Methods	152
7: Vibration Methods	157
8: Weight Methods	161
9: Gas	165

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 9: Level and Density

UNIT 1: Visual Indicators

OPERATIONS	KNOWLEDGE
<hr/>	
1. Installing visual indicators for measuring liquid level	<ul style="list-style-type: none">(a) Interpretation of drawings, specifications and manufacturer's instructions to determine:<ul style="list-style-type: none">(i) type and purpose(ii) material, construction and rating(iii) location, mounting and range of measurement(iv) installation recommendations(b) Importance of adherence to relevant codes and regulations(c) Type and application of visual indicators:<ul style="list-style-type: none">(i) tabular and flat glass gauges(ii) point contact devices and gauge sticks(iii) special purpose gauges (e.g. jacketted for heating and cooling)(d) Type, purpose and construction of gauge valves(e) Methods of mounting and connecting visual indicators and valves(f) Considerations when mounting indicators for:<ul style="list-style-type: none">(i) alignment(ii) rigidity(iii) accessibility(iv) orientation(v) removal facility(g) Type, purpose and use of heating and cooling mediums(h) Methods of installing and connecting tube and pipe(i) Importance of provision of drain and flush facilities(j) Procedures for leak testing gauge installations(k) Type, purpose and methods of aligning:<ul style="list-style-type: none">(i) gauge glass safety guards(ii) remote reading mirrors(iii) calibrated scales(l) Methods of placing in service and checking indicators for correct function

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 9: Level and Density

UNIT 1: Visual Indicators

OPERATIONS	KNOWLEDGE
<hr/>	
1. Installing visual indicators for measuring liquid level (cont'd)	<ul style="list-style-type: none">(m) Importance of avoiding severe thermal shock to gauge glasses(n) Techniques of using and reading visual indicators:<ul style="list-style-type: none">(i) importance of compensating for temperature errors where extreme accuracy of gauge glass reading is required(ii) identification of colours and interfaces(iii) effects of surface tension - meniscus(o) Type, care and use of tools and equipment(p) Mathematics:<ul style="list-style-type: none">(i) linear measure for installation layout(q) Science:<ul style="list-style-type: none">(i) techniques and units of measurement(ii) refraction and reflection(iii) thermal expansion and contraction(iv) stresses(v) density and specific gravity(vi) Pascal's principle and pressure due to head

. MEASUREMENT .

BLOCK 9: Level and Density

UNIT 1: Visual Indicators

OPERATIONS	KNOWLEDGE
2. Servicing visual indicators for measuring liquid level	<ul style="list-style-type: none"> (a) Interpretation of manufacturer's drawings and manuals to determine: <ul style="list-style-type: none"> (i) type, purpose and function (ii) construction and assembly details (iii) recommended servicing procedures (iv) spare parts (b) Procedures for inspecting, dismantling, cleaning, repairing, replacing and assembling visual indicators (c) Importance of checking indicators for: <ul style="list-style-type: none"> (i) leaking seals, gaskets, and joints (ii) cracked or etched glassware (iii) corrosion, fouling and blockage (iv) mechanical wear and damage (d) Methods and considerations in replacement of glassware: <ul style="list-style-type: none"> (i) type, size, material and maximum working pressures and temperature (ii) techniques of cutting and fitting glass (iii) purpose and function of mica protection with flat glasses (iv) importance of avoiding stress on glasses (e) Type, size and material of gaskets and packing materials (f) Methods of cutting, fitting and tightening gaskets and packing (g) Procedures for cleaning visual indicators, gauge valves, reflecting glasses and scales (h) Type, care and use of cleaning agents and inhibitors (i) Techniques and considerations in assembly of gauge glasses: <ul style="list-style-type: none"> (i) importance of cleanliness and correct alignment of parts (ii) sequential procedure of tightening cover nuts and bolts (iii) results of over tightening nuts and bolts (j) Methods and equipment for pressure testing gauge glasses (k) Procedures for testing gauge valves for correct function

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 9: Level and Density

UNIT 1: Visual Indicators

OPERATIONS	KNOWLEDGE
<hr/>	
2. Servicing visual indicators for measuring liquid level (cont'd)	(l) Type and method of lubrication used on point contact devices, tapes, and pulleys (m) Type, care and use of tools: (i) gasket cutters (ii) packing tools (iii) torque wrenches (iv) glass cutters (n) Mathematics: (i) linear measure for sizing glasses, gaskets, etc. (o) Science: (i) corrosion (ii) organic solvents and acids (iii) type of lubricants and their uses (iv) torque (v) units of measurement (vi) flow through pipes

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 9: Level and Density

UNIT 2: Buoyancy

OPERATIONS	KNOWLEDGE
<hr/>	
1. Installing and calibrating buoyancy systems for measuring liquid level and density	<ul style="list-style-type: none">(a) Interpretation of drawings, specifications, and manufacturer's manuals to determine:<ul style="list-style-type: none">(i) type, purpose and application(ii) components; location and mounting(iii) temperature and pressure ratings(iv) measured variable data(v) tube, pipe, and electrical circuit layouts(vi) Principle of operation(vii) suggested calibrating procedures(viii) range of measurement(b) Importance of adherence to relevant codes and regulations(c) Type of applications:<ul style="list-style-type: none">(i) liquid level(ii) liquid density(iii) liquid interface level(d) Type, purpose and function of component<ul style="list-style-type: none">(i) floats, displacers, hydrometers, chambers, wells, cages and valves(ii) torque and flexure tubes, chains, wires, tapes, rods, levers, magnets, and other miscellaneous motion transmission hardware(iii) measurement, transmission and display devices (electrical, mechanical and pneumatic)(e) Methods of installing and securing components(f) Component mounting considerations:<ul style="list-style-type: none">(i) accessibility(ii) orientation(iii) position(g) Importance of careful alignment and plumbing of cages, chambers, guide wires, and miscellaneous transmission hardware(h) Methods of connecting and determining tape, chain, and wire dimensions(i) Methods of installing, supporting, connecting and leak testing pipe and tube(j) Type, purpose and use of liquid seals(k) Procedures for identifying, connecting and testing circuit conductors

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 9: Level and Density

UNIT 2: Buoyancy

OPERATIONS

KNOWLEDGE

1. Installing and calibrating buoyancy systems for measuring liquid level and density (cont'd)

- (l) Techniques of testing electrical and pneumatic measuring and transmitting devices for correct function
- (m) Methods of calibrating, adjusting and placing measuring system in service
- (n) Methods of positioning valves, switches and controls
- (o) Procedures for establishing and applying temperature, specific gravity and level corrections
- (p) Interpretation and use of:
 - (i) gauge glasses
 - (ii) dip sticks and point contact devices
 - (iii) thermometers
 - (iv) hand hydrometers
- (q) Interpretation and adjustment of measurement and display devices
- (r) Type, care and use of electrical test meters
- (s) Type, care and use of tools and equipment
- (t) Mathematics:
 - (i) linear measuring devices and tables for layout
 - (ii) percentage, ratio and proportion to determine calibration adjustment
- (u) Science:
 - (i) scientific measurement
 - (ii) density - specific gravity - buoyancy - hydrometers
 - (iii) temperature indicators and scales
 - (iv) elementary circuitry

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 9: Level and Density

UNIT 2: Buoyancy

OPERATIONS	KNOWLEDGE
<hr/>	
2. Servicing buoyancy systems for measuring liquid level and density	<ul style="list-style-type: none">(a) Interpretation of drawings and manufacturer's literature to determine:<ul style="list-style-type: none">(i) type, purpose and function(ii) operating principle(iii) routine servicing and inspection recommendations(iv) spare parts available(v) electrical and pneumatic circuit details(b) Type, purpose and function of system components:<ul style="list-style-type: none">(i) mechanical(ii) pneumatic(iii) electric(iv) magnetic(c) Procedures for testing, repairing and replacing faulty components(d) Methods of lubricating and inspecting mechanical devices for security and wear:<ul style="list-style-type: none">(i) tapes, chains, rods and wires(ii) pulleys, sheaves and sprockets(iii) bearings, pivots and sliding surfaces(e) Type, care and use of lubricants(f) Methods of flushing and cleaning chambers, wells, cages, glass tubes, floats and displacers(g) Importance of frequent inspection of floats and displacers for leakage due to erosion or corrosion(h) Procedures for cleaning pneumatic and electric measuring and transmitting devices:<ul style="list-style-type: none">(i) nozzles, orifices and adjustable restrictors(ii) pilot relays and baffles(iii) contacts and slidewires(i) Type, care and use of organic solvents(j) Techniques of repacking or replacing stuffing boxes and seals(k) Type, use and limitation of gland packings and "O" ring seals

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 9: Level and Density

UNIT 2: Buoyancy

OPERATIONS

KNOWLEDGE

2. Servicing buoyancy systems for measuring liquid level and density (cont'd)

- (l) Methods of detecting, isolating and repairing tube and pipe leaks
- (m) Procedures for detecting, tracing and rectifying electrical circuit malifunctions
- (n) Methods of establishing and comparing measured variable conditions versus measuring system display
- (o) Type, care and use of electrical test meters, tools and equipment
- (p) Mathematics:
 - (i) linear measure and measuring devices for checking wear and clearances
- (q) Science:
 - (i) type of lubricants and their uses
 - (ii) elementary scientific measurement
 - (iii) density - specific gravity - buoyancy - hydrometers
 - (iv) electricity and electronics
 - (v) corrosion
 - (vi) organic solvents

. MEASUREMENT .

BLOCK 9: Level and Density

UNIT 3: Pressure

OPERATIONS	KNOWLEDGE
1. Installing pressure systems for measuring liquid level and density	<ul style="list-style-type: none"> (a) Interpretation of drawings, specifications and manufacturer's literature to determine: <ul style="list-style-type: none"> (i) type, purpose and application (ii) components; material, location and mounting (iii) tube, pipe and electrical circuit layouts (iv) measured variable and vessel data (v) range span and suppression (vi) principle of operation (b) Importance of adherence to relevant codes and regulations (c) Type of level measuring systems: <ul style="list-style-type: none"> (i) direct hydrostatic (ii) indirect hydrostatic (gas bubble, diaphragm devices) (iii) differential (wet and dry manometer) (d) Type of density measuring systems - differential (gas bubble and liquid purged taps) (e) Type, purpose and function of system components: <ul style="list-style-type: none"> (i) bubble pipes, taps, legs and manifolds (ii) seal, condensate, suppression, reference, diaphragm, surge, bell and measuring chambers (iii) wet and dry measuring and display devices (iv) rotameters, regulators, filters, snubblers, separators, heaters, and valves (v) other (f) Methods of installing components (g) Component mounting considerations: <ul style="list-style-type: none"> (i) orientation (ii) accessibility (iii) position relationships (h) Importance of adequate clearance between bubble pipes and vessel floor (i) Purpose and function of stilling wells and bubble pipe cleanouts (j) Type and purpose of purge system fluids

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 9: Level and Density

UNIT 3: Pressure

OPERATIONS	KNOWLEDGE
<hr/>	
1. Installing pressure systems for measuring liquid level and density (cont'd)	<ul style="list-style-type: none">(k) Procedures for installing and connecting tube and pipe(l) Importance of adherence to pipe and tube layout drawings with regard to elevation, slope and dimensions(m) Results of connecting diaphragm box before stabilization of temperature and pressure conditions(n) Methods of cleaning and leak testing tube and pipe(o) Methods of identifying, connecting and testing electrical conductors(p) Type, care and use of electrical test meters(q) Procedures for placing system in service:<ul style="list-style-type: none">(i) correct positioning of valves and regulators(ii) establishing correct purge flows and supply pressures(iii) techniques of filling reference, seal and suppression chambers(iv) importance of using correct filling fluids(v) methods of venting, filling and zeroing wet and dry manometers(vi) importance of avoiding air locks(vii) interpretation and adjustment of measurement and display devices(r) Mathematics:<ul style="list-style-type: none">(i) linear measure for layout(s) Science:<ul style="list-style-type: none">(i) elementary scientific measurement(ii) pressure due to head(iii) density - specific gravity - hydrometers(iv) Pascal's principle(v) elementary circuitry(vi) voltmeter - ammeter - ohmmeter

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 9: Level and Density

UNIT 3: Pressure

OPERATIONS	KNOWLEDGE
<hr/>	
2. Calibrating pressure systems for measuring liquid level and density	<ul style="list-style-type: none">(a) Interpretation of specifications and manuals to determine:<ul style="list-style-type: none">(i) type and application(ii) recommended calibrating procedures(iii) range, span, suppression and units of measurement(iv) operating principles(v) measured variable and vessel data(b) Type, purpose and function of measuring and display components(c) Type and purpose of calibration(d) Methods of calibrating to recognized standards(e) Type, purpose and function of calibrating devices:<ul style="list-style-type: none">(i) manometers(ii) deadweight testers(iii) test gauges(f) Procedures for connecting calibrating equipment(g) Calculation of span and suppression(h) Importance of reference leg specific gravity to calculation(i) Methods of applying test pressures(j) Interpretation of measuring and display device measurement versus applied calibrating signal(k) Techniques of adjusting for zero, range linearity, span and suppression(l) Effects of low span and suppression ratio on calibration(m) Procedures for adjusting contact closure devices(n) Type, care and use of electrical test meters(o) Methods of field checking and adjusting measurement and display device indications versus established measured variable conditions(p) Procedures and devices for establishing measured variable conditions<ul style="list-style-type: none">(i) hydrometers and thermometers(ii) dip sticks and gauge glasses(iii) head, specific gravity, volume, weight and temperature calculations

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 9: Level and Density

UNIT 3: Pressure

OPERATIONS	KNOWLEDGE
<hr/>	
2. Calibrating pressure systems for measuring liquid level and density (cont'd)	(q) Mathematics: <ul style="list-style-type: none">(i) linear measure to establish liquid level(ii) algebraic equations to calculate span and suppression(iii) percentage, ratio and proportion for calculations to facilitate calibration(iv) area of circle, segment of a circle and volume of cylinder to calculate vessel levels (r) Science: <ul style="list-style-type: none">(i) scientific measurement(ii) density - specific gravity - hydrometers(iii) Pascal's principle(iv) thermal expansion and contraction(v) pressure due to head(vi) elementary circuitry(vii) ohmmeter

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 9: Level and Density

UNIT 3: Pressure

OPERATIONS	KNOWLEDGE
3. Servicing pressure systems for measuring liquid level and density	<ul style="list-style-type: none">(a) Interpretation of manufacturer's literature and relevant handbooks to determine:<ul style="list-style-type: none">(i) type, purpose and operating principles(ii) suggested routine maintenance and servicing procedures(iii) spare parts available(iv) application and range(b) Type, purpose and function of system components(c) Techniques of identifying symptoms of system malfunction(d) Methods of inspecting, testing, repairing and replacing faulty components(e) Procedures and equipment for cleaning and unplugging:<ul style="list-style-type: none">(i) bubble pipes and purged taps(ii) pipe and tube(iii) filters and rotameters(f) Procedures for flushing and filling "hot" and "cold" legs(g) Results and symptoms of plugged bubble pipes, taps, and tubing(h) Methods of inspecting and adjusting purge flows(i) Methods of testing for, locating and repairing system leaks(j) Procedures for checking and correcting zero shift(k) Interpretation of measuring and displacing devices(l) Procedures for cleaning and lubricating mechanical and pneumatic measuring and transmitting devices(m) Type, care and use of organic solvents and lubricants(n) Methods of locating and correcting electrical circuit faults(o) Type, care and use of electrical test meters, tools and equipment(p) Science:<ul style="list-style-type: none">(i) types of lubricants and their uses(ii) organic solvents(iii) elementary scientific measurement(iv) Bernoullis theorem(v) elementary electrical circuitry

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 9: Level and Density

UNIT 4: Dielectric

OPERATIONS	KNOWLEDGE
<hr/>	
1. Installing and calibrating dielectric systems for measuring liquid and solids level	<ul style="list-style-type: none">(a) Interpretation of drawings, specifications and manufacturer's manuals to determine:<ul style="list-style-type: none">(i) type, purpose and application(ii) operating principle(iii) components(iv) material, location and mounting(v) measurement range(vi) electrical circuitry and power requirements(vii) detailed set-up procedures(b) Importance of adherence to relevant codes and regulations(c) Type and purpose of system components:<ul style="list-style-type: none">(i) capacitance probes(ii) transducers and transmitters(iii) oscillators and amplifiers(iv) power supplies and regulators(v) relays and temperature compensators(vi) measurement and display devices(vii) others(d) Methods of installing system components(e) Component mounting considerations:<ul style="list-style-type: none">(i) accessibility(ii) orientation(iii) freedom from vibration(iv) avoidance of extreme ambient conditions(v) distance between components(f) Type of capacitance probes(g) Methods of mounting and securing probes(h) Methods of providing facilities for removing probes from pressured vessels(i) Methods of insulating probes(j) Importance of probe position and immersion(k) Methods of identifying, connecting and testing electrical conductors(l) Type, care and use of electrical test meters(m) Type, purpose and function of:<ul style="list-style-type: none">(i) co-axial cable(ii) conductor shielding

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 9: Level and Density

UNIT 4: Dielectric

OPERATIONS	KNOWLEDGE
<hr/>	
1. Installing and calibrating dielectric systems for measuring liquid and solids level (cont'd)	<ul style="list-style-type: none">(n) Significance of conductor capacity between probe and detection circuits, and its effect on measurement sensitivity(o) Procedures for energizing circuit and setting up measuring system(p) Methods of determining and varying measured variable level or density(q) Techniques of adjusting span and zero controls to synchronize measurement with measured variable(r) Interpretation of measurement and display devices(s) Procedures for determining probe capacitance versus measured variable and recording this data in graph form for future reference(t) Type, care and use of capacitance bridges(u) Methods of calibrating system using:<ul style="list-style-type: none">(i) check capacitors(ii) capacitance decade boxes(iii) capacitance/units of measurement curves(iv) portable potentiometers(v) Type, care and use of tools and equipment(w) Mathematics:<ul style="list-style-type: none">(i) linear measure for layout and level measurement(ii) graphs for recording and calculating calibration data(x) Science:<ul style="list-style-type: none">(i) scientific measurement(ii) density, specific gravity, buoyancy and hydrometers(iii) Pascal's principle(iv) heat transfer(v) temperature indicators and scales(vi) conductors and insulators(vii) distribution and concentration of charges(viii) elementary circuitry(ix) voltmeter, ammeter and ohmmeter(x) electronics(xi) dielectric properties of materials

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 9: Level and Density

UNIT 4: Dielectric

OPERATIONS

KNOWLEDGE

2. Servicing dielectric systems for measuring liquid and solids level
- (a) Interpretation of drawings, manufacturer's literature and relevant handbooks to determine:
 - (i) type and purpose
 - (ii) components
 - (iii) operating principles
 - (iv) measurement range
 - (v) electrical circuit and circuit component detail and values
 - (vi) suggested routine servicing and trouble shooting procedures
 - (vii) recommended spare parts
 - (b) Type, purpose and construction of system components
 - (c) Techniques of recognizing and locating system malfunctions
 - (d) Methods of removing, repairing and replacing faulty components
 - (e) Procedures for testing circuit components and conductors, and establishing adequacy of:
 - (i) resistance
 - (ii) capacitance
 - (iii) voltage
 - (iv) current
 - (v) frequency
 - (vi) insulation
 - (vii) continuity
 - (f) Methods of testing electron tubes and solid state components
 - (g) Type, care and use of electrical test meters:
 - (i) voltohmmeters
 - (ii) vacuum tube voltmeters
 - (iii) capacitance bridges
 - (iv) oscilloscopes
 - (v) meggers
 - (vi) tube testers
 - (h) Techniques of identifying circuit component values and rating by use of colour coding
 - (i) Methods of cleaning slidewires, contact circuit boards and miscellaneous components
 - (j) Type, care and use of organic solvents

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 9: Level and Density

UNIT 4: Dielectric

OPERATIONS	KNOWLEDGE
<hr/>	
2. Servicing dielectric systems for measuring liquid and solids level (cont'd)	<ul style="list-style-type: none">(k) Procedures for inspecting for wear and lubricating display device mechanical drives(l) Type, care and use of lubricants(m) Methods of establishing system accuracy by interpretation of display device indication and measured variable value(n) Significance of high dielectric value of water(o) Type, care and use of tools and equipment(p) Mathematics:<ul style="list-style-type: none">(i) simple algebraic equations, powers and roots for manipulation of ohm's law in establishing voltage, current and resistance relationships and values(q) Science:<ul style="list-style-type: none">(i) types of lubricants and their uses(ii) organic solvents(iii) elementary scientific measurement(iv) density, specific gravity, buoyancy and hydrometers(v) electrostatics(vi) conductors and insulators(vii) theory of electron flow(viii) elementary circuitry(ix) amperage, voltage and resistance(x) ohm's law(xi) voltmeter, ammeter and ohmmeter(xii) electronics(xiii) cathode ray tubes(iiv) gear drives(xv) dielectric values of materials

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 9: Level and Density

UNIT 5: Gamma Ray

OPERATIONS

KNOWLEDGE

1. Installing and calibrating gamma radiation systems for measuring liquid and solids level and density

- (a) Interpretation of drawings, manufacturer's specifications, instructions and manuals to determine:
 - (i) type, purpose and principle of operation
 - (ii) components
 - (iii) location and mounting
 - (iv) circuit arrangement and power requirements
 - (v) calibration and measured variable data
 - (vi) recommended procedures for setting up and placing in service
- (b) Importance of adherence to relevant codes and regulations
- (c) Type, purpose and function of components:
 - (i) sources and source holders
 - (ii) detectors (Geiger Mueller tubes and gas ionization cells)
 - (iii) amplifiers (miscellaneous)
 - (iv) power supplies, rectifiers and converters
 - (v) display devices and controls
- (d) Method of installing components
- (e) Mounting considerations:
 - (i) accessibility
 - (ii) orientation
- (f) Methods of adjustment and significance of positional relationship between sources and detector
- (g) Importance of avoiding high temperature and corrosive conditions
- (h) Methods of identifying and connecting electrical conductors
- (i) Importance of using flexible conductors and conduit at components with position adjustment
- (j) Procedures in testing circuit for continuity, insulation and correct polarity
- (k) Importance of confirming insulation properties of high voltage conductors
- (l) Methods of installing radioactive sources

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 9: Level and Density

UNIT 5: Gamma Ray

OPERATIONS	KNOWLEDGE
<hr/>	
1. Installing and calibrating gamma radiation systems for measuring liquid and solids (cont'd)	<ul style="list-style-type: none">(m) Type, purpose and importance of posting radiation warning signs(n) Techniques of recognizing, storing and handling radioactive sources(o) Importance of avoiding contact or prolonged exposure to radioactive materials(p) Methods and importance of correctly positioning and securing sources in holders(q) Purpose and procedures for system set-up and calibration(r) Type, purpose and method of positioning circuit controls(s) Importance of allowing an adequate system warm-up and stabilization period(t) Methods of measuring and adjusting supply voltages(u) Procedures for adjusting and establishing adequacy of:<ul style="list-style-type: none">(i) source, values and positions(ii) source/detector position relationships(v) Type, care and use of standard sources and equivalent absorbers(w) Techniques of using established measured variable for calibration checks(x) Methods of measuring and adjusting zero, range and sensitivity of output signal and display devices(y) Interpretation of graphs:<ul style="list-style-type: none">(i) signal output curves(ii) gamma radiation absorption curves(z) Interpretation of readout devices, with allowance for random swing(aa) Importance of recording significant calibration data for future checks(bb) Type, care and use of:<ul style="list-style-type: none">(i) electrical test equipment(ii) dosimeters and film badges(iii) tools and equipment

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 9: Level and Density

UNIT 5: Gamma Ray

OPERATIONS

KNOWLEDGE

1. Installing and calibrating gamma radiation systems for measuring liquid and solids level and density (cont'd)

(cc) Mathematics:

- (i) linear measurement for layout
- (ii) graphs for evaluation of signal output values and source versus detector relationship
- (iii) geometry and trigonometry to calculate source values and position with respect to detector

(dd) Science:

- (i) radioactivity
- (ii) biological effects of gamma rays
- (iii) scientific measurement
- (iv) electricity
- (v) electronics
- (vi) corrosion
- (vii) heat transfer
- (viii) ionization of gases
- (ix) density, specific gravity and hydrometers

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 9: Level and Density

UNIT 5: Gamma Ray

OPERATIONS	KNOWLEDGE
<hr/>	
2. Servicing gamma radiation systems for measuring liquid and solids level and density	<ul style="list-style-type: none">(a) Interpretation of circuit drawings, manufacturer's literature and local calibrating records to determine:<ul style="list-style-type: none">(i) type, purpose and application(ii) circuit and source values(iii) suggested testing and servicing procedures(iv) recommended spare parts(v) source/detector relationship data(b) Type, purpose and function of system components(c) Techniques of identifying and isolating system faults(d) Methods of inspecting, testing, repairing and replacing faulty components(e) Importance of frequent inspection of immersed source holders for erosion and cleanliness(f) Methods of applying recommended detector tests(g) Interpretation and application of detector output curves and miscellaneous recorded data(h) Procedures for measuring and establishing circuit values(i) Type, care and use of electrical test instruments:<ul style="list-style-type: none">(i) voltohmmeter(ii) vacuum tube voltmeter(iii) megger(iv) oscilloscope(v) tube tester(j) Procedures and equipment for conducting leakage test of source needles(k) Techniques for detecting radon gas(l) Methods of handling radioactive materials(m) Procedures for cleaning contaminated areas and for disposal of radioactive waste(n) Type, care and use of radiation detection devices:<ul style="list-style-type: none">(i) alpha and gamma meters(ii) dosimeters and film badges

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 9: Level and Density

UNIT 5: Gamma Ray

OPERATIONS

KNOWLEDGE

2. Servicing gamma radiation systems for measuring liquid and solids level and density (cont'd)

- (o) Type, care and use of tools and equipment
- (p) Mathematics:
 - (i) linear measure, geometry and graphs for application and evaluation of detector tests
- (q) Science:
 - (i) electricity
 - (ii) electronics
 - (iii) radioactivity
 - (iv) biological effects of gamma rays
 - (v) scientific measurement

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 9: Level and Density

UNIT 6: Temperature

OPERATIONS	KNOWLEDGE
<hr/>	
1. Installing temperature systems for measuring liquid level and density	<ul style="list-style-type: none">(a) Interpretation of drawings, specifications and manufacturer's literature to establish:<ul style="list-style-type: none">(i) type, purpose and function(ii) system components(iii) material, location and mounting(iv) piping layout(v) electrical circuit layout and power requirements(vi) measurement range(b) Importance of adherence to relevant codes and regulations(c) System type and applications:<ul style="list-style-type: none">(i) boiling point rise (density measurement)(ii) thermal expansion, mechanical and hydraulic (level measurement)(d) Type and purpose of system components:<ul style="list-style-type: none">(i) thermowells, reference temperature and cooling pots(ii) sensing elements, linkages and conductors(iii) measurement and display devices(e) Methods of installing and supporting system components(f) Considerations when mounting components for:<ul style="list-style-type: none">(i) accessibility(ii) orientation(iii) avoidance of extreme temperatures(g) Importance of correct positioning and penetration of thermowells(h) Type, and application of sensing elements:<ul style="list-style-type: none">(i) electrical resistance bulbs(ii) filled systems and generator tubes(iii) mechanical expansion tubes(i) Type, purpose and use of cooling devices with expansion and generator tubes(j) Considerations when mounting sensing elements:<ul style="list-style-type: none">(i) type, purpose and use of thermal conductive materials in thermowells(ii) importance of correct positioning of generator and expansion tubes(iii) methods of anchoring fixed end of expansion tubes

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 9: Level and Density

UNIT 6: Temperature

OPERATIONS	KNOWLEDGE
<hr/>	
1. Installing temperature systems for measuring liquid level and density (cont'd)	<ul style="list-style-type: none">(k) Procedures for connecting expansion tubes to transmitting linkage(l) Methods of installing, connecting, leak testing and filling tube and pipe(m) Importance of compensating for tubing or pipe movement due to temperature change in expansion tube systems(n) Type, purpose and factors influencing choice of hydraulic fluids for generator tube systems(o) Methods of installing, identifying and connecting electrical conductors(p) Effects of measurement from:<ul style="list-style-type: none">(i) conductor length and temperature(ii) electrical interference or pick up(q) Type, purpose and effects of magnetic and electrical shielding(r) Methods of testing conductors for insulation and continuity(s) Techniques of matching and phasing electrical measuring systems(t) Procedures for testing system for correct function(u) Methods of placing in service and adjusting(v) Interpretation of display devices(w) Type, care and use of electrical test meters, tools and equipment(x) Mathematics:<ul style="list-style-type: none">(i) linear measure for layout(ii) measurement of angles for expansion tube positioning(y) Science:<ul style="list-style-type: none">(i) elementary scientific measurement(ii) thermal expansion and contraction(iii) heat transfer(iv) linkages and levers(v) mechanical advantage(vi) electricity(vii) electronics

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 9: Level and Density

UNIT 6: Temperature

OPERATIONS	KNOWLEDGE
<hr/>	
2. Calibrating temperature systems for measuring level and density	<ul style="list-style-type: none">(a) Interpretation of manufacturer's manual to determine:<ul style="list-style-type: none">(i) type and purpose(ii) operating principle(iii) recommended calibrating procedures(iv) range of measurement(b) Type and purpose of calibration(c) Methods of calibrating to recognized standards:<ul style="list-style-type: none">(i) electrical measuring systems(ii) mechanical and hydraulic thermal expansion systems(d) Type, purpose and function of calibrating equipment:<ul style="list-style-type: none">(i) hydrometers(ii) temperature baths(iii) precision thermometers(iv) portable resistance bridges and potentiometers(v) manometers and test gauges(vi) deadweight testers(e) Methods of connecting and applying calibrating devices(f) Procedures of adjusting for zero, range and linearity(g) Significance of length, position and orientation of expansion and generator tubes upon measurement range(h) Methods of setting and adjusting contact closure devices(i) Interpretation of measurement and display devices(j) Techniques of field checking systems using hydrometers, thermometers, and gauge glasses(k) Type, care and use of electrical test meters, tools and equipment

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 9: Level and Density

UNIT 6: Temperature

OPERATIONS

KNOWLEDGE

2. Calibrating temperature systems for measuring level and density (cont'd)

- (1) Mathematics:
 - (i) linear measure for determination of tube length
 - (ii) measurement of angles for orienting tubes
 - (iii) ratio and proportion for lever adjustments during calibration
 - (iv) graph interpretation for resistance/temperature, relationship calculations during calibration
- (m) Science:
 - (i) scientific measurement
 - (ii) temperature indicators and scales
 - (iii) density - specific gravity - hydrometers
 - (iv) linkages and levers
 - (v) mechanical advantage
 - (vi) vapour pressure of liquids
 - (vii) electricity
 - (viii) electronics

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 9: Level and Density

UNIT 6: Temperature

OPERATIONS	KNOWLEDGE
3. Servicing temperature systems for measuring level and density	<ul style="list-style-type: none">(a) Interpretation of drawings, manufacturer's manuals and relevant handbooks to determine:<ul style="list-style-type: none">(i) type and application(ii) operating principle(iii) measured range(iv) electrical circuit detail(v) suggested routine servicing procedures(vi) recommended spare parts(b) Type and purpose of system components(c) Methods of removing, repairing and replacing faulty components(d) Procedures for inspecting mechanical components for corrosion, wear and security(e) Methods of checking pipe, tube and filled systems for leakage and adequate support(f) Methods of flushing and filling sensing tubes, piping and pots(g) Effects of entrained air and solids in liquids(h) Procedures for cleaning and lubricating pivots, bearings and sliding surfaces(i) Type, care and use of lubricants(j) Techniques of testing electrical components and circuits(k) Type, care and use of electrical test meters(l) Methods of cleaning and lubricating contacts and slidewires(m) Type, care and use of organic solvents(n) Type, care and use of tools and equipment(o) Science:<ul style="list-style-type: none">(i) corrosion(ii) friction(iii) types of lubricants and their uses(iv) organic solvents(v) electricity(vi) electronics

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 9: Level and Density

UNIT 7: Vibration

OPERATIONS

KNOWLEDGE

- | | |
|--|--|
| 1. Installing and calibrating vibration systems for measuring liquid level and density | <ul style="list-style-type: none">(a) Interpretation of drawings and manufacturer's manuals to determine:<ul style="list-style-type: none">(i) type, purpose and application(ii) components(iii) material, location and mounting(iv) measured variable and range of measurement(v) electrical circuitry and power requirements(vi) recommended calibration procedures(vii) calibrating data(b) Importance of adherence to relevant codes and regulations(c) Type and function of system components:<ul style="list-style-type: none">(i) detectors(ii) power supplies, amplifiers and relays(iii) measurement and display devices(d) Procedures for installing and securing components(e) Component mounting consideration:<ul style="list-style-type: none">(i) accessibility(ii) orientation(f) Importance of rigid detector mounting(g) Results of extreme ambient conditions at detector:<ul style="list-style-type: none">(i) temperature(ii) corrosion(iii) vibration(h) Importance of careful handling of detector during installation, especially where protective coatings are employed(i) Significance of compliance with maximum distance recommendations between detector and other system components(j) Procedures for identifying, connecting and testing electrical conductors(k) Purpose of shielded conductors(l) Procedures for energizing circuit and ascertaining proper functioning of the system |
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AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 9: Level and Density

UNIT 7: Vibration

OPERATIONS	KNOWLEDGE
<hr/>	
1. Installing and calibrating vibration systems for measuring liquid level and density (cont'd)	(m) Techniques of establishing adequacy of system calibration (n) Methods of changing measured variable (o) Type and use of equipment to establish measured variable values: (i) gauge glasses, point contact devices and dip sticks (ii) hydrometers and thermometers (p) Interpretation of detector signal response curves (q) Procedures for adjusting measurement and display devices (r) Methods of setting potentiometers and contact closures (s) Type, care and use of tools, electrical test meters and equipment (t) Mathematics: (i) linear measure for layout (ii) graphs to interpret signal response curves (u) Science: (i) density, specific gravity and hydrometers (ii) temperature indicators and scales (iii) elementary scientific measurement (iv) electricity (v) elementary electronics

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 9: Level and Density

UNIT 7: Vibration

OPERATIONS	KNOWLEDGE
<hr/>	
2. Servicing vibration systems for measuring liquid level and density	<ul style="list-style-type: none">(a) Interpretation of drawings, manufacturer's manuals and relevant handbooks to determine:<ul style="list-style-type: none">(i) type and application(ii) principle of operation(iii) circuit values and detail(iv) suggested servicing and trouble shooting procedures(v) measurement range(vi) recommended spare parts(b) Type, purpose and construction of system components(c) Techniques of identifying system malfunction(d) Procedures for locating, repairing and replacing faulty components(e) Methods of inspecting and testing detectors for:<ul style="list-style-type: none">(i) mechanical damage(ii) security(iii) corrosion and fouling of paddles(iv) protective coating deterioration(f) Methods of cleaning components, potentiometers and contacts(g) Type, care and use of organic solvents(h) Type, purpose and function of circuit components:<ul style="list-style-type: none">(i) resistors and capacitors(ii) diodes and transistors(iii) thermistors and relays(i) Procedures for testing circuits and components for resistance, insulation, continuity and miscellaneous characteristics(j) Type, care and use of electrical test meters and tools(k) Techniques of confirming and establishing system accuracy(l) Interpretation of measurement and display devices

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 9: Level and Density

UNIT 7: Vibration

OPERATIONS	KNOWLEDGE
<hr/>	
2. Servicing vibration systems for measuring liquid level and density (cont'd)	(m) Science: <ul style="list-style-type: none">(i) scientific measurement(ii) corrosion(iii) organic solvents(iv) specific gravity, density and hydrometers(v) conductors and insulators(vi) theory of electron flow(vii) electromagnetism(viii) amperage, voltage and resistance(ix) voltmeter, ammeter and ohmmeter(x) electronics(xi) vibration and damping

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 9: Level and Density

UNIT 8: Weight

OPERATIONS	KNOWLEDGE
<hr/>	
1. Installing weight systems for measuring liquid density	<ul style="list-style-type: none">(a) Interpretation of drawings and manufacturer's manuals to determine:<ul style="list-style-type: none">(i) type, purpose and function(ii) location and mounting(iii) pipe and tubing layout(iv) electrical circuit layout and power requirements(v) measured variable data(vi) range of measurement(vii) components and materials(b) Importance of adherence to relevant codes and regulations(c) Type and purpose of components:<ul style="list-style-type: none">(i) sample chambers, flow and temperature regulators and indicators(ii) weighing devices(iii) transmission, measurement and display devices(d) Methods of installing and connecting components(e) Type and purpose of sample chamber suspension(f) Importance of alignment, plumbing and clearance at weighing and sample vessel devices(g) Procedures for installing, connecting and leak testing tube and pipe(h) Results of rigid pipe and tube connections at sample chamber(i) Importance of correct elevation of sample piping(j) Methods of identifying, connecting and testing electrical conductors(k) Type and purpose of dashpots and fluids(l) Methods of filling dashpots(m) Procedures for checking system and placing in service(n) Methods of establishing correct flow and temperature conditions(o) Interpretation and adjustment of measuring and display devices(p) Type, care and use of tools, electric test meters and equipment(q) Mathematics -<ul style="list-style-type: none">linear measure for layout

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 9: Level and Density

UNIT 8: Weight

OPERATIONS	KNOWLEDGE
<hr/>	
1. Installing weight systems for measuring liquid density (cont'd)	(r) Science: (i) viscosity ratings of lubricants (ii) elementary scientific measurement (iii) density - specific gravity - buoyancy - hydrometers (iv) thermal expansion and contraction (v) elementary circuitry (vi) mass and weight (vii) pressure due to head (viii) flow through pipes

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 9: Level and Density

UNIT 8: Weight

OPERATIONS	KNOWLEDGE
<hr/>	
2. Calibrating weight systems for measuring liquid density	<ul style="list-style-type: none">(a) Interpretation of manufacturer's literature to establish:<ul style="list-style-type: none">(i) type and purpose(ii) operating principle(iii) range of measurement(iv) recommended calibrating procedures(b) Methods of calibrating system to recognized standards(c) Type, purpose and application of test equipment:<ul style="list-style-type: none">(i) check weights(ii) test gauges and manometers(iii) hydrometers and thermometers(d) Procedures for connecting and applying test equipment(e) Methods of adjusting zero, range and linearity of measuring and display devices(f) Techniques of adjusting contact closure devices(g) Interpretation of display devices(h) Methods of establishing values of measured variable(i) Type, care and use of tools, electrical test meters and equipment(j) Mathematics -<ul style="list-style-type: none">percentage, ratio and proportion to determine calibration adjustments of zero, range and linearity(k) Science:<ul style="list-style-type: none">(i) elementary scientific measurement(ii) density - specific gravity - buoyancy - hydrometers(iii) Pascal's principle(iv) temperature indicators and scales(v) elementary circuitry(vi) linkages and levers

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 9: Level and Density

UNIT 8: Weight

OPERATIONS	KNOWLEDGE
<hr/>	
3. Servicing weight systems for measuring liquid density	<ul style="list-style-type: none">(a) Interpretation of drawings and service manuals to determine:<ul style="list-style-type: none">(i) electric and pneumatic circuit schematics(ii) principle of operation(iii) suggested routine maintenance procedures(iv) spare parts available(b) Procedures for detecting and isolating system faults(c) Methods of inspecting, testing, repairing and replacing faulty components or parts(d) Methods of flushing and cleaning sample system(e) Techniques of checking and adjusting sample temperature and flow(f) Methods of checking sample chamber suspension hardware(g) Procedures in checking for, and eliminating, hysteresis(h) Techniques of inspecting for wear, and methods of cleaning and lubricating:<ul style="list-style-type: none">(i) pivots and bearings(ii) fulcrums and knife edges(i) Type, care and use of organic solvents and lubricants(j) Procedures for tracing and repairing system leaks(k) Methods of locating and rectifying electrical circuit faults(l) Type, care and use of electrical test meters, tools and equipment(m) Science:<ul style="list-style-type: none">(i) types of lubricants and their uses(ii) organic solvents(iii) elementary scientific measurement(iv) temperature indicators and scales(v) elementary circuitry(vi) friction

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 9: Level and Density

UNIT 9: Gas

OPERATIONS

KNOWLEDGE

1. Installing systems for measuring gas density

- (a) Interpretation of drawings, specifications and manufacturer's manuals to determine:
 - (i) type, purpose and function
 - (ii) components; material, location and mounting
 - (iii) electrical circuitry and power requirements
 - (iv) pipe and tubing layout
 - (v) detailed assembly instructions
- (b) Importance of adherence to relevant codes
- (c) Type of systems:
 - (i) weight balance
 - (ii) buoyancy balance
 - (iii) motor driven impellers and blowers (differential)
- (d) System applications:
 - (i) batch, laboratory and portable
 - (ii) continuous
- (e) Methods of installing system components
- (f) Component mounting considerations:
 - (i) accessibility
 - (ii) orientation
 - (iii) freedom from vibration
- (g) Importance of avoidance of extreme ambient conditions and exposure to sunlight
- (h) Procedures and considerations when assembling and setting "balance" assemblies in position:
 - (i) importance of care and cleanliness of parts
 - (ii) methods of levelling
 - (iii) significance of maintaining level
 - (iv) techniques of setting and aligning knife edges, bearings, floats and bells
 - (v) methods of connecting links and levers
 - (vi) removal of shipping stops

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 9: Level and Density

UNIT 9: Gas

OPERATIONS	KNOWLEDGE
<hr/>	
1. Installing systems for measuring gas density (cont'd)	(i) Type of sampling and vent system arrangements (j) Methods of installing, connecting and leak testing tube and pipe of the sample, purge, vent and pneumatic transmission systems (k) Type and purpose of seal oil (l) Methods of filling seal chambers (m) Purpose, use and methods of handling mercury (n) Biological effects of mercury (o) Type, purpose and methods of installing drying agents (p) Procedures for identifying, connecting and testing electrical conductors (q) Procedures for testing system for correct function (r) Methods of positioning valves, regulators and controls (s) Interpretation of measurement and readout facilities (t) Type, care and use of electrical test meters, tools and equipment (u) Mathematics - linear measure for layout (v) Science: (i) scientific measurement (ii) density, specific gravity and buoyancy (iii) elementary circuitry (iv) voltmeter, ammeter and ohmmeter (v) linkages and levers

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 9: Level and Density

UNIT 9: Gas

OPERATIONS

KNOWLEDGE

2. Calibrating systems for measuring gas density

- (a) Interpretation of manufacturer's manual to determine:
 - (i) type, purpose and application
 - (ii) operating principles
 - (iii) recommended calibrating procedures
 - (iv) range of measurement
- (b) Type and purpose of calibration
- (c) Methods of calibrating to recognized standards
- (d) Type and purpose of calibrating equipment:
 - (i) test weights
 - (ii) test gases
 - (iii) manometers
 - (iv) barometers
 - (v) thermometers
- (e) Procedures for applying or connecting calibrating equipment
- (f) Methods of interpreting measurement readout devices and adjusting system to required accuracy
- (g) Important considerations influencing calibration accuracy:
 - (i) methods of ascertaining temperature and barometric pressure and applying correction using compensator graphs
 - (ii) effects of moisture and procedures for removal
 - (iii) effects of hysteresis[†] and friction, and methods of eliminating
 - (iv) results of dirty mercury and techniques of cleaning
 - (v) significance of correct rate of sample flow and methods of adjustment
 - (vi) importance of allowing adequate time for measuring system to achieve equilibrium
- (h) Type, care and use of tools and equipment

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 9: Level and Density

UNIT 9: Gas

OPERATIONS	KNOWLEDGE
<hr/>	
2. Calibrating systems for measuring gas density (cont'd)	(i) Mathematics: <ul style="list-style-type: none">(i) linear measurement to calculate calibration adjustments(ii) graphs for calculation of pressure/temperature compensation (j) Science: <ul style="list-style-type: none">(i) air pressure and its measurement(ii) gas laws(iii) elementary scientific measurement(iv) density, specific gravity and buoyancy(v) temperature indicators and scales(vi) linkages and levers(vii) Bernouilli's theorem

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 9: Level and Density

UNIT 9: Gas

OPERATIONS

KNOWLEDGE

3. Servicing systems for measuring gas density

- (a) Interpretation of drawings, manufacturer's manuals and relevant handbooks to determine:
 - (i) type and purpose
 - (ii) construction
 - (iii) suggested routine servicing procedures
 - (iv) recommended spare parts
 - (v) principle of operation
 - (vi) electrical circuit, pipe and tube layouts
- (b) Type and function of system components and accessories
- (c) Procedures for locating causes of system malfunction
- (d) Methods of removing, repairing and replacing faulty parts
- (e) Techniques of visually inspecting systems for:
 - (i) cleanliness and corrosion
 - (ii) adequate fluid levels
 - (iii) state of dessicant
 - (iv) correct sample flow
 - (v) level
 - (vi) wear of belts, pulleys, pivot bearings, etc.
- (f) Methods and materials for cleaning system parts
- (g) Procedures for lubrication of motor drives and replenishment of seal chambers
- (h) Methods of determining condition of and reactivating and replacing dessicants
- (i) Type, care and use of:
 - (i) organic solvents
 - (ii) lubricants
 - (iii) seal fluids
 - (iv) dessicants
- (j) Methods of leak testing and repairing tubing and pipe
- (k) Procedures for detecting and repairing faults in electrical circuits and components

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 9: Level and Density

UNIT 9: Gas

OPERATIONS	KNOWLEDGE
<hr/>	
3. Servicing systems for measuring gas density (cont'd)	(l) Type, care and use of electrical test meters, tools and equipment (m) Science: <ul style="list-style-type: none">(i) corrosion(ii) type of lubricants and their uses(iii) organic solvents(iv) density, specific gravity and buoyancy(v) gas laws(vi) electric motors(vii) elementary circuitry(viii) voltmeter, ammeter and ohmmeter(ix) belt drive

BLOCK 10: Flow

TABLE OF CONTENTS

UNIT 1:	Pitot Tube	Page 172
2:	Weirs and Parshall Flumes	174
3:	Positive Displacement Meters	176
4:	Head Flow Meters	180
5:	Area Flow Meters	200
6:	Turbine Flow Meters	205
7:	Magnetic Flow Meters	208
8:	Mass Flow Meters	212
9:	Miscellaneous Flow Measuring Techniques	215

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 10: Flow

UNIT 1: Pitot Tube

OPERATIONS	KNOWLEDGE
<hr/>	
1. Measuring liquid and gas flows with a pitot tube	<ul style="list-style-type: none">(a) Interpretation of manufacturer's bulletins, tables and graphs and relevant handbooks(b) Type, characteristic and use of pitot tubes:<ul style="list-style-type: none">(i) single opening(ii) pitot-static(iii) pitot-venturi(iv) combined-reversed(c) Characteristics of flowing liquid gases:<ul style="list-style-type: none">(i) density, pressure and temperature(ii) corrosive properties(iii) presence of entrained solids or liquids(d) Importance of the inside diameter of pipe or dimensions of open channels and ducts(e) Methods of inserting pitot tube in pipe lines under pressure(f) Use of corporation of cocks(g) Methods of determining average gas velocity(h) Methods of filling connecting hoses with flowing liquid(i) Importance of avoiding entrained air or gas in connecting hoses and methods of venting(j) Methods of determining average gas velocity in channels or pipe lines(k) Locations of velocity tip when making a 10-point traverse(l) Methods of checking and importance of correct alignment of velocity tip(m) Procedures for handling velocity tip to avoid damage(n) Methods of inserting pitot tube in duct(o) Type, purpose and characteristics of manometers used for measuring velocity heads:<ul style="list-style-type: none">(i) vertical(ii) inclined(p) Type of manometer fluids and their characteristics

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 10: Flow

UNIT 1: Pitot Tube

OPERATIONS	KNOWLEDGE
<hr/>	
1. Measuring liquid and gas flows with a pitot tube (cont'd)	(q) Methods of connecting their manometer (r) Procedures for operating manometers: (i) alignment (ii) setting zero (use of 3-valve manifold) (iii) reading scales (s) Methods of adjusting and reading liquid fluids and manometers: (i) vertical (ii) inclined (t) Interpretation of flow tables and graphs (u) Mathematics: (i) areas, volumes, for calculation of flow rates (ii) conversion of pressure scales (iii) conversion of gas volumes to standard conditions (iv) powers, roots (v) Science: (i) gas laws (ii) force, mass, acceleration (iii) conservation of energy (iv) Pascal's principle (v) Bernoulli's theorem

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 10: Flow

UNIT 2: Weirs and Parshall Flumes

OPERATIONS	KNOWLEDGE
<hr/>	
1. Measuring liquid flows in open channels	<ul style="list-style-type: none">(a) Type and flow characteristics of primary elements:<ul style="list-style-type: none">(i) rectangular weir(ii) v-notch weir(iii) Cipolletti weir(iv) Parshall flume(b) Head loss characteristics of primary elements(c) Effect of velocity of approach and importance of uniform velocity distribution(d) Methods of obtaining uniform velocity distribution by:<ul style="list-style-type: none">(i) adequate length of straight channel preceding primary element(ii) use of baffles(e) Correct dimension of weirs for complete end and bottom contraction(f) Methods of construction and installation of sharp crested weirs(g) Methods of determining correct size and proportions of weir boxes(h) Use of stillwells and methods of purging(i) Correct location of stillwells(j) Effect of submergence on flow characteristics of Parshall flumes(k) Conditions requiring measurement of both inlet and throat heads for Parshall flumes(l) Correct location of gauging points(m) Methods of measuring head by:<ul style="list-style-type: none">(i) hook gauge(ii) float(iii) bubble tube(n) Type of indicating and recording instruments uses and methods of connection:<ul style="list-style-type: none">(i) float operated(ii) pressure operated

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 10: Flow

UNIT 2: Weirs and Parshall Flumes

OPERATIONS

KNOWLEDGE

1. Measuring liquid flows in
open channels (cont'd)

(o) Mathematics:

- (i) conversion of pressure scales
- (ii) roots, powers, logarithms
- (iii) areas of rectangles, triangles,
trapezoids
- (iv) calculation of flow rates

(p) Science:

- (i) force, mass, acceleration,
gravity
- (ii) Pascal's principle
- (iii) conservation of energy
- (iv) Bernoulli's theorem

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 10: Flow

UNIT 3: Positive Displacement Meters

OPERATIONS	KNOWLEDGE
<hr/>	
1. Repairing diaphragm type gas meters	<ul style="list-style-type: none">(a) Principle of operation and details of construction of common types and makes of gas meters(b) Type and characteristic of case materials:<ul style="list-style-type: none">(i) tin plate(ii) cast iron(iii) pressed steel(iv) aluminum(c) Pressure ratings of meter cases(d) Maximum flow rating of meter(e) Type and characteristic of diaphragm materials:<ul style="list-style-type: none">(i) leather(ii) neoprene(iii) others(f) Methods of dismantling meter and removing working parts(g) Methods of cleaning case and working parts(h) Inspection procedures for:<ul style="list-style-type: none">(i) detecting wear or corrosion(ii) detecting leaks in bellows(i) Methods of repairing or replacing mechanical parts(j) Lubrication procedures(k) Methods of replacing diaphragms(l) Type and use of preservatives for leather diaphragms(m) Methods of grinding valves and use of correct types and grades of valve grinding compounds(n) Procedures and solvents for use in removal of valve grinding compound before assembly of meter(o) Methods of assembly of working parts and case(p) Type of gaskets and methods of fitting, use of sealing compounds(q) Procedures for checking for leaks(r) Procedures for inspection of counter for wear or corrosion of gear train

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 10: Flow

UNIT 3: Positive Displacement Meters

OPERATIONS	KNOWLEDGE
<hr/>	
1. Repairing diaphragm type gas meters (cont'd)	(s) Methods of repairing, replacement and assembly of counter (t) Procedures for checking mechanical parts for binding (u) Mathematics: (i) linear and angular measurements for fitting gaskets (ii) decimals, for checking counters (v) Science: (i) strength of material (ii) corrosion (iii) lubricates and their uses (iv) solvents

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 10: Flow

UNIT 3: Positive Displacement Meters

OPERATIONS	KNOWLEDGE
<hr/>	
2. Calibrating diaphragm type gas meters	<ul style="list-style-type: none">(a) Flow range of meters(b) Pressure rating of meter cases(c) Service conditions:<ul style="list-style-type: none">(i) composition of gas(ii) pressure(iii) temperature(d) Accuracy required(e) Type and use of calibrating equipment:<ul style="list-style-type: none">(i) critical flow prover(ii) Burette type prover(iii) orifice flow meter(iv) gas holder(v) wet test meter(vi) manual and automatic meter provers(f) Methods of connecting and calibrating equipment to meter(g) Use of stopwatch(h) Effects of pressure and temperature of gas on calibration, and methods of correcting meter readings to standard conditions(i) Procedures for ensuring uniform gas temperature and pressure during calibration(j) Methods of making meter adjustment at:<ul style="list-style-type: none">(i) 10 percent flow rate(ii) 50 percent flow rate(iii) 100 percent flow rate(k) Use of thermometers, manometers and pressure gauges(l) Procedures for calibrating and adjusting pressure compensating integrator mechanisms(m) Mathematics:<ul style="list-style-type: none">(i) conversion of pressure scales(ii) conversion of units of volume(iii) calculation of pressure and temperature correction factors(n) Science:<ul style="list-style-type: none">(i) gas laws(ii) molecular theory of gases

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 10: Flow

UNIT 3: Positive Displacement Meters

OPERATIONS	KNOWLEDGE
<hr/>	
3. Repairing and calibrating positive displacement type liquid flow meters	<ul style="list-style-type: none">(a) Interpretation of manufacturer's instruction manuals and relevant handbooks to determine repair and calibration procedures(b) Type, characteristics and uses of positive displacement type meters:<ul style="list-style-type: none">(i) nutating disc(ii) reciprocating piston(iii) sliding vane(iv) rotating vane(v) gear or lobed impeller(vi) ring piston(c) Methods of dismantling meters(d) Procedures for detecting wear and corrosion(e) Methods of cleaning(f) Procedures for replacement of defective parts(g) Methods of assembly(h) Types and use of calibrating equipment:<ul style="list-style-type: none">(i) calibrated tanks(ii) secondary standard meter(i) Methods of connecting meter to calibrating equipment and regulating flow rates(j) Flow range of meter(k) Pressure rating of meter(l) Normal operating pressure(m) Methods of calibrating meter under pressure(n) Mathematics:<ul style="list-style-type: none">(i) calculation of volumes and flow rates(ii) reading, drawing and graphs(o) Science:<ul style="list-style-type: none">(i) mechanism, gears and linkages(ii) fluid flow in pipes(iii) Pascal's principle

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 10: Flow

UNIT 4: Head Flow Meters

OPERATIONS	KNOWLEDGE
1. Installing primary elements for head flow meters	<ul style="list-style-type: none">(a) Interpretation of drawings to determine:<ul style="list-style-type: none">(i) purpose of installation(ii) operating conditions(iii) location(iv) piping size and arrangement(v) type of primary element(b) Principle of operation of primary elements - their characteristics and uses:<ul style="list-style-type: none">(i) concentric orifice(ii) eccentric orifice(iii) segmental orifice(iv) variable area orifice(v) removable orifice(vi) long pattern venturi(vii) short pattern venturi(viii) Dall tube(ix) A.S.M.E. long radius flow nozzle(x) I.S.A. flow nozzle(xi) Pitot tube(xii) Weirs and flumes(c) Method of checking inside diameter of orifice plates, use of inside micrometer calipers(d) Procedures for determining mean inside diameter of pipe(e) Method of checking sharpness of upstream edge of orifice plate(f) Materials of construction of orifice plates and their characteristics:<ul style="list-style-type: none">(i) stainless steel(ii) monel(iii) others(g) Type of orifice flanges and methods of installation:<ul style="list-style-type: none">(i) slip-on(ii) welding neck(h) Dimensions of orifice flanges:<ul style="list-style-type: none">(i) outside diameter(ii) thickness(iii) bolt circle diameter(iv) bolt and bolt hole diameters

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 10: Flow

UNIT 4: Head Flow Meters

OPERATIONS	KNOWLEDGE
<hr/>	
1. Installing primary elements for head flow meters (cont'd)	<ul style="list-style-type: none">(i) Type and thickness of gasket materials and methods of fabrication and fitting(j) Correct location and size of vent and drain holes in orifice plates(k) Location of pressure taps:<ul style="list-style-type: none">(i) vena contracta(ii) flange(iii) radius(iv) corner(v) pipe(l) Use of top or side position of pressure taps(m) Methods of providing connections for pressure taps(n) Correct diameter of drilled holes for pressure taps(o) Methods of finishing inside edge of drilled holes for pressure taps(p) Size and pressure rating of connecting piping(q) Type and size of shut-off valves and methods of installation(r) Use of bevelled orifice plates, correct position of bevelled edge(s) Piping arrangements for acceptable meter accuracy(t) Type, dimension and correct location of straightening vanes(u) Mathematics:<ul style="list-style-type: none">(i) linear and angular measurement for locating pressure taps fitting gaskets, and measuring orifice and pipe diameters(ii) interpretation of graphs to determine minimum lengths of straight pipe adjacent to primary element(v) Science:<ul style="list-style-type: none">(i) fluid flow in pipes(ii) conservation of energy(iii) Bernoulli's theorem

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 10: Flow

UNIT 4: Head Flow Meters

OPERATIONS	KNOWLEDGE
2. Installing head type indicating and recording flow meters	<ul style="list-style-type: none"> (a) Interpretation of drawings to determine: <ul style="list-style-type: none"> (i) purpose of installation (ii) operating conditions (iii) locations (iv) method of mounting and connecting (b) Type, characteristic and use of head type flow meters: <ul style="list-style-type: none"> (i) liquid filled manometers (ii) mercury float (iii) bell (iv) bellows (v) ring balance (vi) pneumatic transmitter (vii) electric transmitter (c) Differential pressure range of meter (d) Static pressure rating of meter body (e) Methods of mounting (f) Methods of installing, connecting, tubing and piping (g) Type, purpose and use of vent and purge valves, settling chambers and catchpots and their correct location (h) Type and use of condensers for steam meters (i) Procedures for mounting and levelling condensers for steam meters (j) Procedures for pressure testing connecting lines (k) Methods of filling lines with flowing liquid or steam condensate - importance of avoiding air locks (l) Use of seal pots and methods of installation (m) Procedures for equalizing differential pressure - correct operation of 3-valve manifold (n) Methods of setting zero meter (o) Procedures for putting meter into operation and checking for leaks (p) Mathematics - <ul style="list-style-type: none"> linear and angular measurement for layout of piping and tubing (q) Science: <ul style="list-style-type: none"> (i) fluid flow in pipes (ii) Pascal's principle

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 10: Flow

UNIT 4: Head Flow Meters

OPERATIONS	KNOWLEDGE
<hr/>	
3. Servicing and maintaining mercury float type and bell type flow meters	<ul style="list-style-type: none">(a) Interpretation of manufacturer's instruction manuals and relevant hand-books to determine servicing procedures(b) Type and characteristic of meters having:<ul style="list-style-type: none">(i) square root scale(ii) linear scale(c) Operating conditions:<ul style="list-style-type: none">(i) properties of flowing fluid(ii) pressure and temperature of flowing fluid(d) Procedures for isolating meter from process stream and equalizing differential pressure(e) Procedure for blowing down, purging and venting connecting lines(f) Causes of slow meter response to changes in flow rate, and their remedies(g) Causes of meter reading consistently high or low and their remedies(h) Methods of adjusting dampening valve(i) Correct lubricants and lubrication procedures(j) Procedures for checking for leaks in connecting lines(k) Methods of dismantling meter(l) Methods of cleaning mechanical linkage(m) Methods of draining and cleaning mercury(n) Methods of removing mercury from chamber walls(o) Procedures for removal, cleaning and replacing pressure tight bearings(p) Procedures for refilling mercury chamber and checking level(q) Methods of removing air or gas trapped under bell(r) Procedures for removal and replacement of Ledoux bell(s) Methods of checking mercury level in meters having a Ledoux bell(t) Mathematics -<ul style="list-style-type: none">powers and roots, for calculating flow rates(u) Science:<ul style="list-style-type: none">(i) fluid flow in pipes(ii) gas laws(iii) Pascal's principle(iv) lubricates and their uses(v) mechanisms, gears

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 10: Flow

UNIT 4: Head Flow Meters

OPERATIONS	KNOWLEDGE
<hr/>	
4. Calibrating mercury float type and bell type flow meters having square root scales	<ul style="list-style-type: none">(a) Interpretation of manufacturer's instruction manuals and relevant hand-books to determine calibration procedures(b) Differential pressure range of meter for:<ul style="list-style-type: none">(i) dry calibration(ii) wet calibration(c) Type and use of test equipment:<ul style="list-style-type: none">(i) water manometer(ii) mercury manometer(d) Methods of connecting manometer to meter(e) Methods of applying test pressure for:<ul style="list-style-type: none">(i) dry calibration(ii) wet calibration(f) Methods of venting entrapped air from calibrating equipment when making wet calibration(g) Method of setting zero(h) Procedures for applying test pressure at 10%, 50% and 100% of differential pressure range(i) Methods of adjusting meter linkages(j) Procedures for detecting excessive friction in linkage system(k) Methods of checking for leaks(l) Mathematics:<ul style="list-style-type: none">(i) conversion of pressure scales(ii) roots, powers, for calculation of flow rates(m) Science:<ul style="list-style-type: none">(i) gas laws(ii) Pascal's principle(iii) mechanisms, levers, linkages, gears

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 10: Flow

UNIT 4: Head Flow Meters

OPERATIONS	KNOWLEDGE
<hr/>	
5. Calibrating mercury float type flow meter having linear scales (Ledoux bell type)	<ul style="list-style-type: none">(a) Interpretation of manufacturer's instruction manuals and relevant handbooks to determine calibration procedures(b) Differential pressure range of meter for:<ul style="list-style-type: none">(i) dry calibration(ii) wet calibration(c) Type and use of test equipment:<ul style="list-style-type: none">(i) water column(ii) water monometer(iii) mercury manometer(d) Methods of connecting test equipment to meter(e) Methods of applying test pressure for:<ul style="list-style-type: none">(i) dry calibration(ii) wet calibration(f) Methods of venting entrapped air from calibration equipment when making wet calibration(g) Methods of removing entrapped air from Ledoux bell(h) Methods of setting zero(i) Procedure for adjusting scale on water column for zero differential pressure(j) Procedure for applying differential pressure equivalent to 70% of chart span(k) Methods of adding or removing mercury to correct errors at 70% of chart span(l) Methods of detecting hysteresis errors due to friction(m) Procedure for applying differential pressure equivalent to 10% of chart span(n) Procedures for adjusting weight of Ledoux bell to correct errors at 10% of chart reading(o) Procedures for checking calibration at 40% of chart span(p) Importance of re-checking meter at zero, 10%, 40% and 70% of chart range(q) Procedure for making final zero check

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 10: Flow

UNIT 4: Head Flow Meters

OPERATIONS	KNOWLEDGE
<hr/>	
5. Calibrating mercury float type flow meter having linear scales (Ledoux bell type) (cont'd)	(r) Mathematics: (i) power, roots, for calculation of flow rates (ii) calculation of differential pressures equivalent to chart readings (s) Science: (i) Pascal's principle (ii) mechanism, levers, linkages

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 10: Flow

UNIT 4: Head Flow Meters

OPERATIONS	KNOWLEDGE
<hr/>	
6. Servicing and maintaining bellow type flow meters	<ul style="list-style-type: none">(a) Interpretation of manufacturer's instruction manuals to determine servicing procedures(b) Type and characteristics of bellows meters:<ul style="list-style-type: none">(i) single bellows (aneroid)(ii) double bellows(c) Operating conditions:<ul style="list-style-type: none">(i) properties of flowing fluid(ii) pressure and temperature of flowing fluid(d) Procedures for isolating meter from process stream and equalizing differential pressure(e) Procedures for blowing down, purging and venting connecting lines(f) Causes of slow meter response to changes in flow rates and their remedies(g) Causes of meter reading consistently high or low and their remedies(h) Procedures for checking for leaks in connecting lines(i) Methods of dismantling meter body(j) Procedures for cleaning bellows chamber(k) Methods of changing range spring(l) Procedures for removing bellows units from meter(m) Type and characteristic of liquids used for filling bellows(n) Procedures for filling and re-assembly of bellows units(o) Importance of removing air bubbles from bellows during assembly(p) Methods of testing bellows for completeness of fill(q) Procedures for detecting excessive friction in mechanical linkages, and methods of removal(r) Methods of adjusting dampening valve(s) Procedures for changing torque tube in aneroid type meters(t) Characteristics of bellows materials

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 10: Flow

UNIT 4: Head Flow Meters

OPERATIONS	KNOWLEDGE
<hr/>	
6. Servicing and maintaining bellow type flow meters (cont'd)	(u) Pressure ratings and length of bellows for aneroid type meters (v) Procedures for replacing bellows in aneroid type meters (w) Methods of checking performance of meter after assembly (x) Mathematics: (i) linear measurement for assembly of components (y) Science: (i) Pascal's principle (ii) static and sliding friction, lubrication (iii) linkages, levers (iv) flow through pipes (v) elasticity, spring rates

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 10: Flow

UNIT 4: Head Flow Meters

OPERATIONS

KNOWLEDGE

7. Calibrating bellows type flow meters

- (a) Interpretation of manufacturer's instruction manuals and relevant handbooks to determine calibration procedures
- (b) Differential pressure range of meter
- (c) Procedures for using calibrating manometer
- (d) Method of applying test pressure:
 - (i) low pressure air supply
 - (ii) bulb
- (e) Method of connecting manometer to meter
- (f) Correct position of dampening valve during calibration
- (g) Procedures for checking calibration at 10%, 50% and 100% of meter range
- (h) Methods of setting zero
- (i) Methods of adjusting length of drive arm to correct errors in range of meter
- (j) Procedures for detecting hysteresis errors
- (k) Importance of repeating zero and range checks until required accuracy is obtained
- (l) Methods of replacing plugs after calibration - use of thread compounds
- (m) Methods of changing differential range
- (n) Mathematics:
 - (i) conversion of pressure scales
 - (ii) powers, roots, for calculation of flow rates
- (o) Science:
 - (i) mechanism, levers, linkages, springs
 - (ii) gas laws

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 10: Flow

UNIT 4: Head Flow Meters

OPERATIONS	KNOWLEDGE
<hr/>	
8. Servicing and maintaining ring balance type flow meter	<ul style="list-style-type: none">(a) Interpretation of manufacturer's instruction manuals to determine servicing procedures(b) Operating conditions:<ul style="list-style-type: none">(i) properties of flowing fluid(ii) pressure and temperature of flowing fluid(c) Differential pressure range of meter(d) Pressure rating of meter ring(e) Type and characteristic of sealing liquid used(f) Procedures for isolating meter from process stream and equalizing differential pressure(g) Procedures for blowing down, purging and venting connecting lines(h) Methods of cleaning meter mechanism(i) Importance of avoiding damage to flexible connections during cleaning(j) Procedures for draining, cleaning and re-filling ring(k) Science:<ul style="list-style-type: none">(i) gas laws(ii) fluid flow in pipes(iii) Pascal's principle(iv) static and sliding friction(v) solvents(vi) moments, torque

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 10: Flow

UNIT 4: Head Flow Meters

OPERATIONS

KNOWLEDGE

9. Calibrating ring balance
type flow meters

- (a) Interpretation of manufacturer's instruction manuals and relevant handbooks to determine calibration procedures
- (b) Differential pressure range of meter for dry calibration
- (c) Methods of calibration using:
 - (i) water manometer
 - (ii) calibrating weights
- (d) Methods of connecting manometer to meter
- (e) Procedures for applying test pressure:
 - (i) low pressure air supply
 - (ii) bulb
- (f) Methods of using calibrating weights for:
 - (i) zero reading
 - (ii) up-scale readings
- (g) Methods of setting zero
- (h) Methods of making range adjustments
- (i) Importance of repeating zero and range adjustments until required accuracy is obtained
- (j) Mathematics:
 - (i) conversion of pressure scales
 - (ii) powers and roots for calculation of flow rates
- (k) Science:
 - (i) gas laws
 - (ii) moments, torque

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 10: Flow

UNIT 4: Head Flow Meters

OPERATIONS	KNOWLEDGE
<hr/>	
10. Calibrating a pneumatic force balance type flow transmitter	<ul style="list-style-type: none">(a) Interpretation of manufacturer's instruction manuals to determine calibration procedures(b) Differential pressure range of transmitter(c) Methods of calibration, using a water manometer and a mercury manometer(d) Procedures for setting zero and adjusting output pressure equivalent to zero flow(e) Procedures for regulating test pressure equivalent to 10%, 50% and 100% of transmitter range(f) Methods of adjusting output air pressure to correct values for 10%, 50% and 100% of transmitter range(g) Methods of locking range adjustment(h) Importance of re-checking zero and range adjustments until required accuracy is obtained(i) Mathematics -<ul style="list-style-type: none">calculation of test pressures(j) Science:<ul style="list-style-type: none">(i) gas laws(ii) linkages, levers

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 10: Flow

UNIT 4: Head Flow Meters

OPERATIONS

KNOWLEDGE

11. Calibrating a differential transformer and receiver

- (a) Interpretation of manufacturer's instruction manuals to determine calibration procedures
- (b) Differential pressure range of transmitter
- (c) Methods of calibration, using a water or mercury manometer and regulated air supply
- (d) Method of adjusting zero
- (e) Procedures for applying test pressure equivalent to 10%, 50% and 100% of recorder range
- (f) Methods of making range adjustments
- (g) Methods of making electrical connections from transmitter to receiver
- (h) Methods of adjusting receiver pen or pointer drive arm
- (i) Importance of re-checking zero and range adjustments until required accuracy is obtained
- (j) Mathematics -
conversion of pressure scales
- (k) Science -
basic electricity, magnetism, inductance, transformers

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 10: Flow

UNIT 4: Head Flow Meters

OPERATIONS	KNOWLEDGE
<hr/>	
12. Calibrating an electrical type flow transmitter	<ul style="list-style-type: none">(a) Interpretation of manufacturer's instruction manuals to determine calibration procedures(b) Differential pressure range of transmitter(c) Type of electrical output of transmitter:<ul style="list-style-type: none">(i) voltage(ii) current(d) Range of transmitter output(e) Method of calibration using a manometer and regulated air supply(f) Care and use of electrical measuring instruments:<ul style="list-style-type: none">(i) voltmeter(ii) milliammeter(iii) portable potentiometer(g) Methods of adjusting zero of transmitter(h) Methods of applying test pressure equal to maximum differential pressure(i) Methods of connecting electrical measuring instruments to transmitter output(j) Procedures for reading electrical output(k) Methods of adjusting range of transmitter(l) Importance of re-checking zero and range adjustments(m) Mathematics -<ul style="list-style-type: none">conversion of pressure scales(n) Science -<ul style="list-style-type: none">basic electricity and electronics

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 10: Flow

UNIT 4: Head Flow Meters

OPERATIONS	KNOWLEDGE
13. Calibrating a steam-flow air-flow recording meter	<ul style="list-style-type: none">(a) Interpretation of manufacturer's instruction manuals and relevant handbooks to determine calibration procedures(b) Procedures for calibrating mercury-float and bell type flowmeters(c) Preliminary procedures required to ensure:<ul style="list-style-type: none">(i) correct draft line connections(ii) correct operation of boiler outlet damper, feed water regulator and furnace draft controller(iii) proper condition of baffle and boiler walls(iv) constant feed water temperature(v) constant steam pressure(vi) suitability of plant operating conditions for calibration check(d) Procedures for adjusting fuel and air flows at 30% boiler capacity(e) Methods of making boiler outlet gas analysis for oxygen, CO₂ and CO, use of Orsat apparatus(f) Procedures for adjusting fuel and air to obtain best possible combustion efficiency(g) Methods of setting air-flow pen to coincide with steam-flow pen(h) Methods of adjusting air-flow pen stop(i) Methods of setting air-flow pen at zero by adjusting balance weights(j) Importance of re-checking relative position of air-flow and steam-flow pens after setting air-flow pen at zero(k) Procedures for repeating calibration check at 60% and 80% of boiler capacity(l) Procedures for using balance weights on air-flow mechanism to obtain preliminary calibration curve(m) Interpretation of combustion air curves for:<ul style="list-style-type: none">(i) coal(ii) oil(iii) natural or coke oven gas

. MEASUREMENT .

BLOCK 10: Flow

UNIT 4: Head Flow Meters

OPERATIONS	KNOWLEDGE
13. Calibrating a steam-flow air-flow recording meter (cont'd)	<ul style="list-style-type: none">(n) Procedures for calculating correct air-flow readings and drawing final calibration curve(o) Methods of making final adjustment to air-flow pen by:<ul style="list-style-type: none">(i) changing pen mechanism radius(ii) adding or removing mercury from reservoir(iii) changing position of balance weights(p) Mathematics:<ul style="list-style-type: none">(i) calculating volumes, percentages(ii) cartesian co-ordinates, reading graphs(q) Science:<ul style="list-style-type: none">(i) mechanics, levers, linkages, moments(ii) combustion and fuels(iii) law of combining gas volumes (Gay Lussacs)

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 10: Flow

UNIT 4: Head Flow Meters

OPERATIONS	KNOWLEDGE
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14. Computing total flows from recorder charts	<ul style="list-style-type: none">(a) Type of chart records:<ul style="list-style-type: none">(i) square root flow record(ii) linear flow record(iii) differential pressure record(b) Range of flowmeter(c) Chart factor(d) Methods of calculating total flows by:<ul style="list-style-type: none">(i) chart inspection(ii) planimeter(e) Type care and use of planimeters:<ul style="list-style-type: none">(i) radial(ii) square root for circular charts(iii) square root for miniature strip charts(iv) combination differential and static pressure(f) Methods of checking planimeter accuracy(g) Methods of correcting total flow readings for variations in pressure and temperature of flowing gases(h) Mathematics:<ul style="list-style-type: none">(i) powers, roots for calculating total flows(ii) conversion of volume and weights units(iii) calculation of areas(i) Science:<ul style="list-style-type: none">(i) Boyles Law(ii) Charles Law(iii) elementary scientific

. MEASUREMENT .

BLOCK 10: Flow

UNIT 4: Head Flow Meters

OPERATIONS	KNOWLEDGE
<hr/>	
15. Repairing and calibrating automatic flow integrators	<ul style="list-style-type: none">(a) Interpretation of manufacturer's instructional manuals, repairs and calibration procedures(b) Methods of automatic integration:<ul style="list-style-type: none">(i) intermittent(ii) continuous(c) Type and characteristic of integrators:<ul style="list-style-type: none">(i) mechanical(ii) electrical(iii) electronic(iv) pneumatic(d) Range of flowmeter(e) Integrator factor(f) Procedures for inspection for:<ul style="list-style-type: none">(i) wear(ii) corrosion(iii) mechanical, electrical or pneumatic faults(g) Methods of dismantling and cleaning(h) Methods of repair or replacement of defective parts(i) Methods of assembly(j) Procedures for checking accuracy of integrator using:<ul style="list-style-type: none">(i) planimeter(ii) fixed pen position(k) Methods of adjusting counting rates(l) Mathematics -<ul style="list-style-type: none">calculation of integrator factors

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 10: Flow

UNIT 4: Head Flow Meters

OPERATIONS

KNOWLEDGE

16. Calibrating a pneumatic
square root converter

- (a) Interpretation of manufacturer's instruction manuals to determine calibration procedures
- (b) Principle of operation
- (c) Type and use of calibrating equipment:
 - (i) mercury manometers
 - (ii) accurate pressure gauges
- (d) Methods of connecting calibrating equipment and regulated air supply to converter
- (e) Procedures for stabilizing output pressure by:
 - (i) use of correct length and diameter of tubing
 - (ii) use of volume chamber
- (f) Accuracy required
- (g) Procedures for applying input pressure
- (h) Methods of adjusting output air pressures equivalent to:
 - (i) zero flow
 - (ii) intermediate flows
 - (iii) maximum flow
- (i) Procedures for correcting non-linearity in output pressure
- (j) Methods of adjusting indicator pointer
- (k) Mathematics -
 - powers and roots for calculation of output pressures

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 10: Flow

UNIT 5: Area Flow Meters

OPERATIONS	KNOWLEDGE
<hr/>	
1. Selecting and installing an area type flowmeter	<ul style="list-style-type: none">(a) Interpretation of drawings to determine:<ul style="list-style-type: none">(i) purpose(ii) location(iii) service conditions(iv) method of mounting and connecting(b) Type and characteristic of area meters:<ul style="list-style-type: none">(i) rotameter(ii) piston(iii) orifice and plug(c) Materials of construction of end fittings and bodies and their properties(d) Type of end connections and methods of assembly:<ul style="list-style-type: none">(i) threaded(ii) flanged(iii) tube and clamp(e) Pressure and temperature ratings of rotameter tubes:<ul style="list-style-type: none">(i) glass(ii) metal(iii) ceramic and others(f) Type and flow characteristic of rotameter floats:<ul style="list-style-type: none">(i) spherical(ii) plumb-bob(iii) spool(iv) viscosity immune(g) Use of corrosion resistant materials(h) Methods of shielding rotameter tubes(i) Standard sizes and capacity ratings of rotameter tubes(j) Indicating and recording methods:<ul style="list-style-type: none">(i) direct viewing(ii) float extension rod(iii) magnetic, electric or pneumatic transmitting(k) Type and characteristic of gland packings and methods of installing(l) Procedures for tightening gland nuts, importance of avoiding strain on glass tubing(m) Type and characteristic of gasket materials and methods of cutting and fitting

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 10: Flow

UNIT 5: Area Flow Meters

OPERATIONS

KNOWLEDGE

1. Selecting and installing an area type flowmeter (cont'd)

- (n) Methods of assembling air supply systems, use of pressure regulators, filters, dryers, catchpots and vent valves
- (o) Methods of checking for leaks in pneumatic systems
- (p) Methods of installing electrical wiring importance of adherence to relevant codes and regulations
- (q) Effects of electromagnetic fields and methods of shielding
- (r) Use of electrical test equipment for checking circuits after installation
- (s) Mathematics:
 - (i) linear and angular measurements for layout and fitting
 - (ii) conversion of volume units and calculation of flow rates
- (t) Science:
 - (i) gas laws
 - (ii) Pascal's principle
 - (iii) fluid flow in pipes
 - (iv) properties of materials - ferrous and non-ferrous alloys, glass, ceramics
 - (v) atmospheric corrosion
 - (vi) basic electricity

. MEASUREMENT .

BLOCK 10: Flow

UNIT 5: Area Flow Meters

OPERATIONS	KNOWLEDGE
2. Calibrating an area flow meter	<ul style="list-style-type: none"> (a) Interpretation of manufacturer's instruction manuals to determine calibration procedures (b) Properties and characteristics of measured fluid: <ul style="list-style-type: none"> (i) chemical composition (ii) density (iii) viscosity (c) Flow, pressure and temperature (d) Minimum, maximum and normal flow rates (e) Methods of calibration for liquid flows by: <ul style="list-style-type: none"> (i) weight (ii) volume (iii) secondary standard flow meter (f) Methods of calibration for gas flows by: <ul style="list-style-type: none"> (i) volume (gasholder or prover) (ii) secondary standard flow meter (g) Methods of connecting area meter to calibrating equipment (h) Methods of controlling flow rate, pressure and temperature of fluid used for calibration (i) Methods of calculating equivalent flow of process fluid from air or water calibration (j) Effect on calibration of: <ul style="list-style-type: none"> (i) float diameter (ii) specific gravity of float material (iii) shape of float (iv) weight of float (k) Common float materials and their characteristics (l) Effect of fluid viscosity on calibration - use of viscosity immune floats (m) Procedures for calibrating magnetic, electric and pneumatic transmitters (n) Methods of aligning transmitters and indicating or recording receivers (o) Procedures for checking and adjusting integrators (p) Type of alarm actuating devices and methods of adjustment

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 10: Flow

UNIT 5: Area Flow Meters

OPERATIONS	KNOWLEDGE
<hr/>	
2. Calibrating an area flow meter (cont'd)	<ul style="list-style-type: none">(q) Mathematics:<ul style="list-style-type: none">(i) conversion of volume and weight units(ii) calculation of correction factors for pressure, temperature and specific gravity(iii) powers and roots(iv) reading, drawing and graphs(v) calculation of float diameters and weights(r) Science:<ul style="list-style-type: none">(i) force, mass, acceleration, gravity(ii) density, specific gravity, viscosity, buoyancy(iii) gas laws(iv) Pascal's principle(v) conservation of energy, Bernoulli's Theorem(vi) magnetism, electricity(vii) theory of election flow

. MEASUREMENT .

BLOCK 10: Flow

UNIT 5: Area Flow Meters

OPERATIONS	KNOWLEDGE
3. Servicing and maintaining an area flow meter	<ul style="list-style-type: none"> (a) Service conditions: <ul style="list-style-type: none"> (i) chemical and physical properties of flowing fluid (ii) operating pressure and temperature of flowing fluid (b) Methods of isolating meter from process stream (c) Procedures for venting and purging meters (d) Methods of removing floats from rotameters (e) Methods of checking floats for corrosion or erosion - use of micrometer calipers (f) Methods of removing and installing rotameter tubes (g) Procedures for cleaning rotameter tubes and floats (h) Type and characteristic of rotameter gland packings (i) Procedure for removing and fitting gland packings and tightening gland nuts (j) Importance of avoiding strain on glass tubing when tightening gland nuts (k) Procedures for checking and aligning indicating, recording and transmitting devices: <ul style="list-style-type: none"> (i) magnetic (ii) electric (iii) pneumatic (l) Procedures for testing for electrical faults - use of test equipment (m) Type of air filters and filter materials, methods of replacement (n) Methods of checking pneumatic circuits for air leaks or blockages (o) Mathematics - <ul style="list-style-type: none"> linear and angular measurements for checking float sizes and fitting gaskets and gland packings (p) Science: <ul style="list-style-type: none"> (i) atmospheric and galvanic corrosion (ii) properties of materials (iii) gas laws (iv) basic electricity

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 10: Flow

UNIT 6: Turbine Flow Meters

OPERATIONS

KNOWLEDGE

1. Calibrating a turbine
flow meter

- (a) Interpretation of manufacturer's instruction manuals and relevant handbooks to determine calibration procedures
- (b) Principle of operation
- (c) Flow range of meter
- (d) Flow rate equivalent to 60 or 120 cps signal
- (e) Use of line frequency as a calibration standard
- (f) Selection of correct calibration frequency
- (g) Methods of adjusting range register
- (h) Methods of calibration by means of an electronic counter and measured volumes of weights of water
- (i) Mathematics:
 - (i) calculation of flow rates
 - (ii) conversion of volume and weight units
- (j) Science:
 - (i) basic electricity
 - (ii) theory of electron flow

. MEASUREMENT .

BLOCK 10: Flow

UNIT 6: Turbine Flow Meters

OPERATIONS	KNOWLEDGE
2. Installing a turbine flow meter	<ul style="list-style-type: none"> (a) Interpretation of drawings to determine: <ul style="list-style-type: none"> (i) purpose of installation (ii) location of sensing element (iii) location of indicator or recorder and method of mounting (b) Interpretation of manufacturer's instruction manuals and wiring diagrams (c) Type, size and characteristic of sensing elements (d) Method of connection of sensing element: <ul style="list-style-type: none"> (i) screwed fittings (ii) flanged fittings (e) Type and size of screwed and flanged fittings and methods of assembly (f) Use of thread compounds (g) Type of gasket materials, and methods of cutting and fitting (h) Procedures for tightening screwed and flanged connections (i) Type and size of electrical wiring required and methods of installation (j) Effects of electromagnetic and electrostatic fields and methods of shielding (k) Importance of adherence to relevant electrical codes and regulations (l) Mathematics - <ul style="list-style-type: none"> linear and angular measurement for layout of piping, wiring and fitting gaskets (m) Science: <ul style="list-style-type: none"> (i) fluid flow in pipes (ii) impulse of liquid jets (iii) basic electricity

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 10: Flow

UNIT 6: Turbine Flow Meters

OPERATIONS

KNOWLEDGE

3. Servicing a turbine flow meter

- (a) Interpretation of manufacturer's instruction manuals to determine service procedures
- (b) Methods of dismantling and assembling flow sensing element
- (c) Methods of inspection of bearings and rotor for wear and procedures for replacement of parts
- (d) Causes of erratic meter readings and remedies
- (e) Causes of meter reading consistently high or low and remedies
- (f) Type of electronic tubes used and procedures for checking and replacement
- (g) Use of oscilloscope for circuit analysis
- (h) Methods of checking and servicing frequency converters, amplifiers, counters, power supplies, potentiometers and other electronic components
- (i) Mathematics:
 - (i) conversion of volume and weight units
 - (ii) use of decimals for calculating flow rates
- (j) Science:
 - (i) basic electricity
 - (ii) theory of electron flow

. MEASUREMENT .

BLOCK 10: Flow

UNIT 7: Magnetic Flow Meters

OPERATIONS	KNOWLEDGE
1. Installing a magnetic flow meter	<ul style="list-style-type: none"> (a) Interpretation of drawings to determine: <ul style="list-style-type: none"> (i) purpose of installation (ii) location of transmitter and receiver (iii) method of mounting (b) Interpretation of manufacturer's instruction manuals and wiring diagrams (c) Principle of operation of magnetic flow meter (d) Materials of construction of meter tubes and their characteristics (e) Materials of construction of tube lining, their physical and chemical properties and temperature limitations (f) Type and size of end connections: <ul style="list-style-type: none"> (i) screwed (ii) flanged (g) Type of thread compounds and their use (h) Type of gasket materials and methods of cutting and fitting (i) Methods of making screwed and flanged connections and testing for leaks (j) Methods of installation of meter tube to ensure complete filling (k) Size of wire required for power supply and connecting leads and methods of installation (l) Effect of length of connecting leads on meter accuracy (m) Effects of electromagnetic and electrostatic fields, and methods of shielding (n) Effects of interference from other circuits connected to the meter circuit (o) Type and size of conduit required (p) Methods of grounding meter and conduit (q) Methods of ensuring electrical contact between conduit and transmitter and receiver case (r) Importance of adherences to relevant electrical codes and regulations

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 10: Flow

UNIT 7: Magnetic Flow Meters

OPERATIONS

KNOWLEDGE

1. Installing a magnetic
flow meter (cont'd)

(s) Mathematics:

linear and angular measurements
for installation of meter tube,
electrical wiring, and fitting
gaskets

(t) Science:

- (i) A.C. electricity
- (ii) electromagnetic induction,
Faraday's law
- (iii) theory of electron flow

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 10: Flow

UNIT 7: Magnetic Flow Meters

OPERATIONS	KNOWLEDGE
<hr/>	
2. Servicing a magnetic flow meter	<ul style="list-style-type: none">(a) Interpretation of manufacturer's instruction manuals and wiring diagrams to determine service procedures(b) Operating conditions - physical and chemical properties of flowing liquid(c) Procedure for removing meter tube from process line(d) Methods of cleaning tube(e) Methods of detecting dirty electrodes(f) Methods of cleaning electrodes(g) Methods of checking tube lining by means of brine solution and ohmmeter(h) Methods of checking electrodes for shorts to ground(i) Methods of repairing or replacing defective linkages and pivots in recorder(j) Methods of checking and repairing faulty range unit(k) Use of electrical test equipment for checking electrical circuits:<ul style="list-style-type: none">(i) ohmmeter(ii) Wheatstone bridge(iii) vacuum tube voltmeter(iv) oscilloscope(l) Methods of correcting faults in dashpot and characteristics of dashpot oils(m) Methods of removing air bubbles from oil in dashpot and adjusting level(n) Methods of adjusting meter range(o) Methods of checking vacuum tubes using ohmmeter(p) Science:<ul style="list-style-type: none">(i) A.C. electricity(ii) electromagnetic induction, Faraday's law(iii) theory of electron flow

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 10: Flow

UNIT 7: Magnetic Flow Meter

OPERATIONS

KNOWLEDGE

3. Calibrating a magnetic
flow meter

- (a) Interpretation of manufacturer's instruction manuals to determine calibration procedures
- (b) Methods of calibration using an **adjustable** millivolt source
- (c) Methods of calibration with water using volume or weight tanks
- (d) Methods of changing range of meter
- (e) Mathematics:
 - (i) conversion of volume and weight units
 - (ii) calculation of areas, volume, flow rates
- (f) Science:
 - (i) A.C. electricity
 - (ii) Faraday's law
 - (iii) theory of electron flow

. MEASUREMENT .

BLOCK 10: Flow

UNIT 8: Mass Flow Meters

OPERATIONS	KNOWLEDGE
1. Measuring true mass flows of liquid and gases by direct means	<ul style="list-style-type: none"> (a) Interpretation of manufacturer's instruction manuals to determine: <ul style="list-style-type: none"> (i) installation (ii) servicing (iii) calibration (b) Type and characteristic of mass flow meters: <ul style="list-style-type: none"> (i) axial flow (ii) radial flow (iii) gyroscopic (c) Methods of providing fluid momentum (d) Methods of sensing fluid momentum (e) Methods of integration (f) Pressure and temperature limitations and effect of ambient temperature (g) Effect of suspended solids in flowing fluid (h) Effect of viscosity of fluid (i) Mathematics - <ul style="list-style-type: none"> conversion of volume and weight units (j) Science: <ul style="list-style-type: none"> (i) conservation of energy, force, mass acceleration (ii) coriolis acceleration (iii) principle of the gyroscope (iv) mechanics, gears, levers (v) A.C. electricity, magnetism

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 10: Flow

UNIT 8: Mass Flow Meters

OPERATIONS

KNOWLEDGE

2. Measuring mass flow rates of liquids by indirect means

- (a) Interpretation of manufacturer's instruction manuals to determine:
 - (i) installation
 - (ii) servicing
 - (iii) calibration
- (b) Methods of measuring volumetric flow rates of liquids by:
 - (i) head flow meters
 - (ii) area flow meters
 - (iii) turbine flow meters
 - (iv) magnetic flow meters
 - (v) acoustic velocity flow meters
 - (vi) vortex-velocity flow meters
- (c) Methods of measuring density of flowing liquids by:
 - (i) buoyancy
 - (ii) differential pressure
 - (iii) radiation absorption
 - (iv) electrical conductivity
 - (v) vibration
 - (vi) piezoelectric crystal
- (d) Type of analog computers used for calculating mass flow rates:
 - (i) mechanical
 - (ii) pneumatic
 - (iii) electrical
- (e) Type of indicating and recording instruments
- (f) Mathematics:
 - (i) conversion of volume and weight units
 - (ii) calculation of densities
- (g) Science:
 - (i) conservation of energy, Bernoulli's theorem
 - (ii) electricity, electromagnetic induction
 - (iii) electronics
 - (iv) vibration and sound
 - (v) radio-isotopes
 - (vi) Archimedes principle

. MEASUREMENT .

BLOCK 10: Flow

UNIT 8: Mass Flow Meters

OPERATIONS	KNOWLEDGE
3. Measuring mass flow rates of gases by indirect means	<ul style="list-style-type: none"> (a) Interpretation of manufacturer's instruction manuals, and piping and wiring diagrams (b) Methods of measuring volumetric flow rates of gases by means of: <ul style="list-style-type: none"> (i) head flow meters (ii) area flow meters (iii) turbine flow meters (c) Methods of measuring gas pressure using: <ul style="list-style-type: none"> (i) manometers (ii) bellows and diaphragm gauges (iii) bourdon spring gauges (iv) electrical transducers (d) Methods of measuring gas temperatures using: <ul style="list-style-type: none"> (i) filled system thermometers (ii) pyrometers (iii) resistance thermometers (e) Methods of transmitting flow, pressure and temperature readings (f) Type characteristic and function of square root converters and analog computers used for calculating mass flow rates: <ul style="list-style-type: none"> (i) mechanical (ii) pneumatic (iii) electrical (g) Procedures for calibrating, installing and servicing flow, pressure and temperature measuring and transmitting instruments (h) Methods of connecting transmitters to computer (i) Methods of calibrating computer output (j) Mathematics: <ul style="list-style-type: none"> (i) powers, roots, logarithms (ii) calculation of pressure and temperature correction factors (k) Science: <ul style="list-style-type: none"> (i) conservation of energy, Bernoulli's theorem (ii) gas laws, molecular theory of gases (iii) fluid dynamics (iv) Pascal's principle (v) levers, linkages, gears (vi) A.C. and D.C. electricity (vii) theory of electron flow

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 10: Flow

UNIT 9: Miscellaneous Flow Measuring
Techniques

OPERATIONS

KNOWLEDGE

1. Measuring liquid flow rates
by acoustic methods

- (a) Interpretation of manufacturer's instruction manuals to determine:
 - (i) calibration
 - (ii) installation
 - (iii) servicing
- (b) Characteristics and uses of acoustic flow meters
- (c) Effect of solid particles and of air bubbles on operation of meter
- (d) Mathematics:
 - calculation of volumes and flow rates
- (e) Science:
 - (i) vibration, sound, Doppler effect beat frequencies
 - (ii) piezoelectric effect
 - (iii) theory of electron flow

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 10: Flow

UNIT 9: Miscellaneous Flow Measuring
Techniques

OPERATIONS	KNOWLEDGE
2. Measuring gas flows with thermal conductivity type flow meters	<ul style="list-style-type: none">(a) Interpretation of manufacturer's operating and maintenance instructions to determine:<ul style="list-style-type: none">(i) installation(ii) calibration(iii) maintenance(b) Type and characteristic of flow sensing elements:<ul style="list-style-type: none">(i) heated resistance(ii) heated thermopiles(c) Type and characteristics of flow indicators and recorders:<ul style="list-style-type: none">(i) millivoltmeter(ii) Wheatstone bridge(iii) manuals or self-balancing potentiometer(d) Type and use of probes:<ul style="list-style-type: none">(i) directional(ii) non-directional(e) Materials of construction of probes and their corrosion resistant properties(f) Methods of installing probes in pipes or ducts(g) Methods of cleaning probes(h) Science:<ul style="list-style-type: none">(i) thermal conductivity(ii) basic electricity, Wheatstone bridge, potentiometer(iii) theory of electron flow

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 10: Flow

UNIT 9: Miscellaneous Flow Measuring
Techniques

OPERATIONS

KNOWLEDGE

- | | |
|---|---|
| 3. Measuring fluid flows with a vortex-velocity type flow meter | <ul style="list-style-type: none">(a) Interpretation of manufacturer's instruction manuals to determine:<ul style="list-style-type: none">(i) installation(ii) calibration(iii) maintenance(b) Size and flow ranges of meter bodies(c) Materials of construction of meter bodies(d) Methods of making connections:<ul style="list-style-type: none">(i) threaded ends(ii) flanged ends(e) Pressure ratings of meter bodies(f) Methods of readout:<ul style="list-style-type: none">(i) direct totalizing(ii) remote indicating, recording and totalizing(g) Procedures for removing and replacing rotors(h) Methods of purging bearings(i) Length and size of straight pipe required adjacent to meter body(j) Procedures for lubricating bearings under pressure:<ul style="list-style-type: none">(i) manually(ii) automatically(k) Mathematics -<ul style="list-style-type: none">calculation of volumes and weights(l) Science:<ul style="list-style-type: none">(i) basic electricity(ii) theory of electron flow(iii) fluid flow in pipes |
|---|---|

. MEASUREMENT .

BLOCK 10: Flow

UNIT 9: Miscellaneous Flow Measuring
Techniques

OPERATIONS	KNOWLEDGE
4. Measuring liquid flows with a target type flowmeter	<ul style="list-style-type: none"> (a) Interpretation of manufacturer's instruction manuals to determine: <ul style="list-style-type: none"> (i) installation (ii) calibration (iii) maintenance (b) Flow ranges for various pipe sizes (c) Fluid velocity limitations (d) Pressure and temperature limitations of flow sensing element (e) Principle of operation of a bonded strain gauge transducer (f) Type and characteristic of indicating and recording instruments: <ul style="list-style-type: none"> (i) direct reading indicator (ii) self-balancing potentiometer (iii) oscilloscope (iv) pneumatic (g) Methods of mounting sensing element in pipe lines (h) Methods of making electrical connections from transducer to indicating or recording instrument (i) Mathematics - <ul style="list-style-type: none"> powers and roots calculation of flow rates (j) Science: <ul style="list-style-type: none"> (i) force, mass, acceleration (ii) basic electricity, Ohm's law, Wheatstone bridge, strain gauges (iii) theory of electron flow (iv) fluid flow in pipes Bernoulli's theorem

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 10: Flow

UNIT 9: Miscellaneous Flow Measuring
Techniques

OPERATIONS

KNOWLEDGE

5. Measuring fluid flows with
an elbow meter

- (a) Characteristics and uses of elbow flow meters
- (b) Correct location of pressure taps
- (c) Methods of making pressure connections
- (d) Selection of suitable types of indicating or recording differential pressure meter
- (e) Type and size of connecting piping and tubing and methods of installation
- (f) Methods of providing means of draining, blowing down or purging connecting lines
- (g) Methods of installing indicating and recording flow meters:
 - (i) field mounted
 - (ii) panel mounted
- (h) Procedures for calibration by:
 - (i) pitot traverse
 - (ii) secondary standard meter
- (i) Mathematics -
 - calculation of flow rates
- (j) Science:
 - (i) force, mass, acceleration
 - (ii) conservation of energy
 - (iii) Boyles law, Charles law

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE
. MEASUREMENT .

BLOCK 11: Viscosity and Consistency

TABLE OF CONTENTS

UNIT 1: Continuous Systems	Page 221
2: Batch or Lab Type	232

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 11: Viscosisty and
Consistency

UNIT 1: Continuous Systems

OPERATIONS

KNOWLEDGE

1. Installing components

- (a) Interpretation of drawings and specifications to determine:
 - (i) location of components
 - (ii) identification of process system
 - (iii) process flow
 - (iv) schematics for instrument and electrical components
 - (v) piping tank, or chamber details
 - (vi) fluid type, pressure, and temperature
- (b) Interpretation of manufacturer's literature to determine:
 - (i) recommended installation procedure and details
 - (ii) flow, pressure, and temperature limits of measured fluid
 - (iii) limits of ambient conditions
 - (iv) assembly details
 - (v) adjustment details
 - (vi) range limits and values
 - (vii) connecting details
 - (viii) effects of poor installation on accuracy
 - (ix) principle of operation
- (c) Type, size and principle of non-rotating consistency sensing elements:
 - (i) friction loss in pipe lines
 - (ii) submerged force - balanced shear floats
 - (iii) bouyant floats
 - (iv) fixed screen plates
 - (v) flow and counterflow or friction tubes
 - (vi) combinations of (iii) and (v)
 - (vii) hydraulic gradient in open channels
 - (viii) others
- (d) Type, size and principle of rotating consistency sensing elements:
 - (i) agitator drives on chests or storage tanks
 - (ii) small motor driven feeler blades
 - (iii) motor driven discs
 - (iv) motor driven drum screens
 - (v) hydraulically driven paraboloids
 - (vi) others

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 11: Viscosity and
Consistency

UNIT 1: Continuous Systems

OPERATIONS	KNOWLEDGE
1. Installing components (cont'd)	<ul style="list-style-type: none">(e) Type, size and principle of electrical or electrically operated consistency sensing elements:<ul style="list-style-type: none">(i) electrical resonance(ii) vibrating blade(iii) photo-cell(iv) bolometer(v) others(f) Type, size and principle of viscosity sensing elements:<ul style="list-style-type: none">(i) rotational(ii) semi-continuous piston(iii) float(iv) vibrating probe(v) capillary tube(vi) others(g) Methods of installing in process lines various types of chambers for sensing elements(h) Importance of vertical and horizontal alignment of sensing element chambers(i) Comparison of partial flow and total flow chambers and methods of installing sample lines(j) Type of common variables developed by viscosity and consistency sending elements and chambers and used to determine consistency or viscosity variations:<ul style="list-style-type: none">(i) hydrostatic head(ii) differential hydrostatic head(iii) level(iv) torque(v) motion (moving linkages)(vi) power consumption(vii) others(k) Type, size, principle of operation and methods of installing devices to measure common variables:<ul style="list-style-type: none">(i) floats(ii) bubble tubes(iii) filled systems(iv) direct head meters(v) pneumatic motion transmitter(vi) pneumatic force balance transmitter (head type)(vii) pneumatic force balance transmitter (torque)(viii) others

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 11: Viscosity and
Consistency

UNIT 1: Continuous Systems

OPERATIONS

KNOWLEDGE

1. Installing components
(cont'd)

- (l) Methods of installing wattmeters
(thermoconverters)
- (m) Type, size and method of installing:
 - (i) radiant energy detectors (optical)
 - (ii) energy absorption detectors
 - (iii) visual float viscosimeters
 - (iv) by-pass visual float rotameters
- (n) Effects of flow, temperature, and
particle size on consistency and
viscosity measurement
- (o) Principles of operation and methods of
installing temperature compensating
components
- (p) Methods of installing flow measuring
components
- (q) Principles of operation and methods of
installing measurement display component:
 - (i) indicating
 - (ii) recording
- (r) Procedures for mixing dilution medium
with process fluid
- (s) Methods of installing diffuser nozzles
or pipe-line mixers in process fluid
- (t) Procedures for installing accessories
- (u) Methods of installing, tubing, wiring
and mounting components
- (v) Methods of testing components after
installation
- (w) Mathematics:
 - (i) linear measurement for making
layout, tubing runs adjustments
 - (ii) circular and angular measurements
to calculate layout and alignment
procedure
 - (iii) ratio and proportion to calculate
adjustment of linkages
 - (iv) powers and roots to compute flow
measurement, torque, force and
power relations
 - (v) elementary algebra to convert
simple relations in hydraulics,
electric circuits and mechanical
motion

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 11: Viscosity and
Consistency

UNIT 1: Continuous Systems

OPERATIONS	KNOWLEDGE
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1. Installing components (cont'd)	(x) Science: (i) principle of turning moment (ii) linkages, ratchets, cams and levers (iii) mechanical advantage of simple machines (iv) torque (v) static and sliding friction (vi) worm and wheel (vii) gear drivers

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 11: Viscosity and
Consistency

UNIT 1: Continuous Systems

OPERATIONS

KNOWLEDGE

2. Calibrating components

- (a) Interpretation of drawings and specifications to determine:
 - (i) location of components
 - (ii) instrument and electrical schematics
 - (iii) transmission runs
 - (iv) piping runs
 - (v) chests and pumps
 - (vi) sample points
 - (vii) fluid pressure, temperature and flow
- (b) Interpretation of manufacturer's literature to determine:
 - (i) assembly details
 - (ii) adjustment details
 - (iii) connection details
 - (iv) range limits and values
 - (v) service requirements
- (c) Type, purpose and function of test equipment; primary and secondary standards - portable and shop
- (d) Use of test equipment to provide or measure signals of:
 - (i) pressure
 - (ii) temperature
 - (iii) flow
 - (iv) electrical quantities
- (e) Laboratory techniques and equipment to determine fluid properties:
 - (i) specific gravity and density
 - (ii) viscosity
 - (iii) consistency
 - (iv) concentration
- (f) Industrial standards and procedures for obtaining fluid samples and determining viscosity or consistency
- (g) Application and use of precision linear measurement devices
- (h) Methods of adjusting springs in tension and compression or changing spring rate
- (i) Procedures for altering the mechanical advantage of lever systems

. MEASUREMENT .

BLOCK 11: Viscosity and
Consistency

UNIT 1: Continuous Systems

OPERATIONS	KNOWLEDGE
2. Calibrating components (cont'd)	<ul style="list-style-type: none"> (j) Methods of changing the specific gravity or viscosity rating of submerged floats (k) Methods of changing the linear or angular ratio between rack and pinion or gear trains (l) Importance of pre-checking pneumatic or electrical transmission runs for leaks or grounds (m) Use of fluid testing techniques to determine correct operating ranges of sensing elements (n) Methods of adjusting transmitters for: <ul style="list-style-type: none"> (i) zero (ii) span (iii) linearity (o) Methods of adjusting sensing components for correct range by altering: <ul style="list-style-type: none"> (i) floats (ii) float linkages (iii) motion arms (iv) force arms or balance (v) weight balance (vi) fluid gates or level (vii) sensing element submersion depth (viii) others (p) Methods of adjusting read-out display units: <ul style="list-style-type: none"> (i) pressure gauges (ii) pressure recorders (iii) electronic receivers, indicating or recording (q) Methods of adjusting read-out display units for: <ul style="list-style-type: none"> (i) zero (ii) span (iii) linearity (iv) sensitivity (r) Type and principle of control components and control modes

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 11: Viscosity and
Consistency

UNIT 1: Continuous Systems

OPERATIONS

KNOWLEDGE

2. Calibrating components

- (s) Methods of calibrating and adjusting controller settings
- (t) Methods of calibrating final control elements:
 - (i) float operated valves
 - (ii) electro-pneumatic or pneumatic valve positioners
 - (iii) control valves
 - (iv) others
- (u) Mathematics:
 - (i) linear area, and volumetric measurements to determine adjustments and calculate hydraulic, pneumatic and electrical values
 - (ii) ratio and proportion, powers and roots to determine adjustments and principles of operation
 - (iii) curves, graphs, and algebra to interpret manufacturer's literature and pilot results
 - (iv) rate, per cent to determine flows, change and consistency
 - (v) properties of circle and triangle to determine function and adjustment of linkages
 - (vi) geometric shapes to determine volumes or displacements
- (v) Science:
 - (i) linear and angular speed
 - (ii) torque, force, mass
 - (iii) linkages, mechanical advantage
 - (iv) gears and gear trains
 - (v) elements of rheology
 - (vi) basic electronics
 - (vii) basic hydraulics
 - (viii) basic control theory

. MEASUREMENT .

BLOCK 11: Viscosity and
Consistency

UNIT 1: Continuous Systems

OPERATIONS	KNOWLEDGE
3. Servicing components	<ul style="list-style-type: none"> (a) Interpretation of drawings and specifications to determine: <ul style="list-style-type: none"> (i) location (ii) instrument and electrical schematics (iii) transmission and piping runs (iv) chests and pumping details (v) sample points (vi) fluid type, pressure, temperature and flow (vii) component sizes (b) Interpretation of manufacturer's literature to determine: <ul style="list-style-type: none"> (i) type and principle of operation (ii) assembly and adjustment details (iii) services required (iv) range limits and values (v) connection details (vi) parts identification (c) Type, size, material and method of repairing or replacing: <ul style="list-style-type: none"> (i) raceways (ii) pneumatic or hydraulic tubing (iii) metal fasteners and locking devices (iv) tubing connectors and seals (v) pipe and pipe fittings (d) Type, size, material and method of repairing or replacing: <ul style="list-style-type: none"> (i) conduit and conduit racks or supports (ii) signal or power wires and accessories (iii) wiring connectors and terminal strips (e) Methods of repairing or replacing: <ul style="list-style-type: none"> (i) bearings, plain or antifriction (ii) gears and gear trains (iii) rack and pinions (iv) slides (v) seals; pressurized or non-pressurized (vi) mounting brackets (f) Importance of proper fit and alignment of bearings and seals on shafts or linkages

. MEASUREMENT .

BLOCK 11: Viscosity and
Consistency

UNIT 1: Continuous Systems

OPERATIONS

KNOWLEDGE

3. Servicing components
(cont'd)

- (g) Methods of repairing or replacing component parts of force or motion transmitters:
 - (i) pneumatic
 - (ii) electrical
- (h) Procedures for repairing or replacing sensing elements:
 - (i) rotating blades or discs
 - (ii) floats and float linkages
 - (iii) light sources
 - (iv) photo-cells
 - (v) bolometers
 - (vi) electric, pneumatic or hydraulic motors
- (i) Methods of repairing or replacing component parts of electronic measurement circuits:
 - (i) thermo-convertors
 - (ii) amplifiers
 - (iii) slide wires
 - (iv) transformers
 - (v) electron tubes
 - (vi) servo-motors
 - (vii) others
- (j) Type and method of repairing or replacing component parts of display units:
 - (i) indicating
 - (ii) recording
- (k) Procedures for cleaning and repairing small component parts:
 - (i) pneumatic pilot relays
 - (ii) electrical relays
 - (iii) electrical contacts, stationary or moving
 - (iv) others
- (l) Methods of repairing or replacing component parts of pneumatic or electronic controllers:
 - (i) blind
 - (ii) indicating
 - (iii) recording
- (m) Type of electro-mechanical devices used to convert electrical signals to pneumatic signals

. MEASUREMENT .

BLOCK 11: Viscosity and
Consistency

UNIT 1: Continuous Systems

OPERATIONS	KNOWLEDGE
3. Servicing components (cont'd)	<ul style="list-style-type: none"> (n) Importance of cleaning and lubricating: <ul style="list-style-type: none"> (i) bearings (ii) gear trains (iii) servo motors (iv) slides (v) seals (o) Type, use and limit of lubricants (p) Methods of replacing or repairing component parts of glass devices: <ul style="list-style-type: none"> (i) glass tubes (ii) floats (iii) seals (iv) scales (q) Methods of repairing or replacing component parts of electronic temperature compensation systems: <ul style="list-style-type: none"> (i) wells (ii) resistance bulbs (iii) slidewires (iv) potentiometers (v) electron tubes (r) Type, size and method of repairing or replacing component parts of final control elements: <ul style="list-style-type: none"> (i) electro-pneumatic transducers (ii) positioner linkages, springs, bellows, pilot relays, boosters relays, gauges (iii) air service reducing valves (iv) pneumatic, hydraulic, or electric motors (v) control valves; inner valves, stems, stuffing boxes, packing, seats, gaskets, actuator springs and diaphragms (vi) cylinder and piston actuators (vii) worm and spur gears (viii) rack and pinion (ix) chain and cable linkages (x) sliding or rotating gates (xi) others (s) Type, use and principle of test equipment: <ul style="list-style-type: none"> (i) electrical (ii) pneumatic (iii) hydraulic

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 11: Viscosity and
Consistency

UNIT 1: Continuous Systems

OPERATIONS

KNOWLEDGE

3. Servicing components
(cont'd)

- (t) Methods of testing or trouble-shooting system or system components
- (u) Industrial standards for defining and determining consistency and viscosity
- (v) Techniques of process sampling
- (w) Mathematics:
 - (i) linear, area and volumetric measurements to determine linkage lengths, fluid velocities
 - (ii) ratio and proportion to determine linkage amplification or signal gains
 - (iii) rate and per cent to determine signal vs. dial values and consistency
 - (iv) properties of circle and triangle to determine relations between circular and linear measurement
 - (v) curves, graphs, algebra to plot, read, and interpolate results of tests and convert signal values
 - (vi) geometric shapes to determine displacement values
- (x) Science:
 - (i) linear and angular speed
 - (ii) torque, force, mass
 - (iii) fluid properties
 - (iv) gears and gear trains
 - (v) elements of rheology
 - (vi) basic electronics
 - (vii) basic hydraulics
 - (viii) basic control theory
 - (ix) lubricants and their uses
 - (x) lubricant deterioration

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 11: Viscosity and
Consistency

UNIT 2: Batch or Lab Type

OPERATIONS	KNOWLEDGE
1. Servicing viscometers	<ul style="list-style-type: none">(a) Interpretation of manufacturer's literature to determine:<ul style="list-style-type: none">(i) type and principles of operation(ii) assembly and operating details(iii) identification of parts(iv) viscosity and temperature range(b) Type, use and principle of operation:<ul style="list-style-type: none">(i) sliding plate(ii) rotating disc(iii) concentric cylinder(iv) capillary(v) orifice(vi) falling ball(vii) rising bubble(viii) piston(ix) vibrating reed(x) others(c) Type and use of standard oils(d) Care and use of stop watches(e) Effects of temperature variations(f) Methods of controlling temperature through the use of:<ul style="list-style-type: none">(i) oil baths(ii) water baths(iii) resistance bulbs(iv) simple thermostatic controls(v) precision electronic controls(g) Procedures for adjusting working volumes of test fluid(h) Type, use and purpose of electric timers and timing circuits(i) Effects of fluid density(j) Importance and methods of cleaning viscometers(k) Methods of levelling viscometers(l) Methods of repairing or replacing servo-motors(m) Methods of repairing or replacing pivots and bearings(n) Methods of replacing and testing electron tubes(o) Procedures for repairing or replacing hydraulic connectors

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 11: Viscosity and
Consistency

UNIT 2: Batch or Lab Type

OPERATIONS

KNOWLEDGE

1. Servicing viscometers
(cont'd)

- (p) Methods of repairing pressure gauges
- (q) Mathematics:
 - (i) linear, area, and volumetric measurement to calculate viscosity and viscosity measurement
 - (ii) curves, graphs, algebra
 - (iii) powers, roots, ratio and proportion
 - (iv) conversion values
- (r) Science:
 - (i) elements of rheology
 - (ii) viscosity terminology
 - (iii) fluid flow and properties
 - (iv) temperature scales
 - (v) basic electronics

BLOCK 12: Weight - Force - Load

TABLE OF CONTENTS

UNIT 1: Weight, Batch or Sample	Page 235
2: Continuous Weight Scales	239
3: Force and Load	248

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 12: Weight - Force - Load UNIT 1: Weight, Batch or Sample

OPERATIONS

KNOWLEDGE

1. Installing scales

- (a) Interpretation of drawings and specifications to determine:
 - (i) location of components
 - (ii) function
 - (iii) structural mounting details at location
 - (iv) service details
- (b) Interpretation of manufacturer's literature to determine:
 - (i) assembling details
 - (ii) connecting details
 - (iii) principles of operation
 - (iv) methods of adjustment
 - (v) recommended installation details and procedures
- (c) Type, size, range and principle of operation of scales:
 - (i) bench
 - (ii) hook
 - (iii) portable platform
 - (iv) small platform
 - (v) large platform (truck)
 - (vi) process sample
 - (vii) hopper or tank
 - (viii) others
- (d) Class, purpose and function of levers and lever systems
- (e) Importance of providing suitable foundation
- (f) Methods and importance of levelling small scales
- (g) Methods of installing and assembling platform scales:
 - (i) pivots
 - (ii) ways
 - (iii) main levers
 - (iv) shelf, beam and pendulum levers
 - (v) balance weights
 - (vi) dashpot
 - (vii) head mechanism
 - (viii) platform
 - (ix) hydraulic load cells
 - (x) pneumatic load cells
 - (xi) strain gauge load cells
 - (xii) pressure indicators
 - (xiii) electronic measuring circuits
 - (xiv) electronic indicators

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 12: Weight - Force - Load UNIT 1: Weight, Batch or Sample

OPERATIONS	KNOWLEDGE
<hr/>	
1. Installing scales (cont'd)	<ul style="list-style-type: none">(h) Methods of fitting ways and knife edges to level main levers(i) Use of flexure plates at pivot or fulcrum points(j) Methods of installing hook scale components:<ul style="list-style-type: none">(i) hydraulic rams(ii) flexible hydraulic lines and connectors(iii) air bleed connections(iv) pressure gauges(v) strain gauge load cells(vi) shielded cable(vii) electronic indicators or recorders(k) Procedures for installing load cells on tanks or hoppers(l) Type and use of radioactive sources and electronic circuits for determining basis-weight of materials such as paper cellophane, etc., from sample strips(m) Type, size and use of metal fasteners(n) Importance of cleanliness when assembling and installing weighing component(o) Type, size and use of springs scales(p) Methods of compensating for temperature variations(q) Mathematics:<ul style="list-style-type: none">(i) linear and weight measurements to calculate force, mechanical advantage and installation requirements(ii) formula to calculate electrical values(r) Science:<ul style="list-style-type: none">(i) mass and weight definition(ii) levers(iii) mechanical advantage(iv) elementary circuitry(v) basic electronics(vi) radio-isotopes(vii) Pascal's principle

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 12: Weight - Force - Load UNIT 1: Weight, Batch or Sample

OPERATIONS

KNOWLEDGE

2. Calibrating scales

- (a) Interpretation of manufacturer's literature to determine:
 - (i) principles of operation
 - (ii) methods of adjustment
 - (iii) limits of accuracy
- (b) Use of standard weights:
 - (i) certified
 - (ii) uncertified
- (c) Methods of equalizing platform scales at corners by adjusting ways and knife edges
- (d) Importance of cleanliness
- (e) Methods of adjusting balance weights and levers systems
- (f) Methods of adjusting dials and head mechanisms
- (g) Procedures for calibrating:
 - (i) pressure gauges
 - (ii) pneumatic or hydraulic pressure recorders
- (h) Methods of calibrating electronic recorders
- (i) Use of calibrating standards:
 - (i) hydraulic and pneumatic
 - (ii) electrical and electronic
 - (iii) test samples
- (j) Effects of temperature variation
- (k) Methods of adjusting for tare weight
- (l) Mathematics:
 - (i) linear and weight measurement to calculate force and mechanical advantage
 - (ii) formula to calculate electrical values
- (m) Science:
 - (i) levers and mechanical advantage
 - (ii) units of weight and mass
 - (iii) Pascal's principle
 - (iv) force and pressure
 - (v) elementary circuitry
 - (vi) basic electronics
 - (vii) department of weights and measures standards

. MEASUREMENT .

BLOCK 12: Weight - Force - Load UNIT 1: Weight, Batch or Sample

OPERATIONS	KNOWLEDGE
<hr/>	
3. Servicing scales	<ul style="list-style-type: none">(a) Interpretation of manufacturer's literature to determine:<ul style="list-style-type: none">(i) parts identification(ii) assembly procedure(iii) lubrication procedure(b) Methods of repairing or replacing component parts:<ul style="list-style-type: none">(i) knife edges and ways(ii) levers(iii) flexure plates(iv) bearings(v) rack and pinions(vi) sector ribbons(vii) metal fasteners(viii) electron tubes(ix) load cells(x) servo-motors(xi) others(c) Type and use of lubricants and dashpot fluids(d) Type and use of test equipment:<ul style="list-style-type: none">(i) pneumatic and hydraulic(ii) electrical(e) Effects of friction and misalignment(f) Importance of cleanliness(g) Mathematics:<ul style="list-style-type: none">(i) linear and weight measurement to calculate force and mechanical advantage(ii) formula to calculate electrical values(h) Science:<ul style="list-style-type: none">(i) levers and mechanical advantage(ii) units of weight and mass(iii) Pascal's principle(iv) force and pressure(v) elementary circuitry(vi) basic electronics(vii) lubricants and cleaning fluids

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 12: Weight - Force - Load

UNIT 2: Continuous Weigh Scales

OPERATIONS

KNOWLEDGE

1. Installing continuous weigh scales

- (a) Interpretation of drawings and specifications to determine:
 - (i) location
 - (ii) structural details
 - (iii) function
 - (iv) services required
- (b) Interpretation of manufacturer's literature to determine:
 - (i) type and accuracy
 - (ii) principle of operation
 - (iii) assembling details
 - (iv) recommended procedures and requirements for installing
- (c) Type, range and principle of operation:
 - (i) continuous strip-weighers; mechanical, radio-isotope
 - (ii) conveyor-belt weighers; mechanical, electro-mechanical, pneumatic, radio-isotope
 - (iii) continuous feeders
 - (iv) others
- (d) Procedures for adjusting elevation and aligning approach and retreat idlers on conveyor belts
- (e) Importance of correct tracking and tension control of conveyor belts
- (f) Effects of different troughing angles of conveyor belts
- (g) Methods of installing weigh section of conveyor belts:
 - (i) structural members
 - (ii) pivots or knife edges
 - (iii) longitudinal and lateral restraining links
 - (iv) conveyor idlers
 - (v) sensing rods to balance mechanism
 - (vi) load cells; electric, pneumatic
- (h) Importance of electing matching idlers for weigh section

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 12: Weight - Force - Load

UNIT 2: Continuous Weigh Scales

OPERATIONS	KNOWLEDGE
1. Installing continuous weigh scales (cont'd)	<ul style="list-style-type: none"> (i) Type and method of installing balance components: <ul style="list-style-type: none"> (i) supports and housing (ii) shafts, links, and levers (iii) pivots (iv) counterpoise weights (v) floats and mercury wells (vi) electrical or pneumatic transmission lines (vii) electronic balance bridges and housing (viii) pneumatic force balance diaphragm (ix) others (j) Type, principle and method of installing integrating components: <ul style="list-style-type: none"> (i) speed rolls (ii) spur gears and chains (iii) tachometers (iv) bearings, plain or anti-friction (v) weight connecting links (vi) cone and wheel integrators or tilting and non-tilting integrators discs (vii) belt or motor drives for integrators (viii) counter mechanisms (ix) power cylinders and controls for wheel on non-tilting disc (x) electronic integrators (xi) pneumatic and electric transmission lines (xii) remote digital totalizers (k) Methods of installing rate recorders, indicators, and transducers in panels or field mountings (l) Procedures for installing radio-isotope conveyor-belt weigher component: <ul style="list-style-type: none"> (i) measuring assembly (ii) tachometer (iii) power supply (iv) indicators and recorders (v) totalizers (vi) electrical transmission runs

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 12: Weight - Force - Load UNIT 2: Continuous Weigh Scales

OPERATIONS

KNOWLEDGE

1. Installing continuous weigh scales (cont'd)
- (m) Methods of reducing hazards of radio-active sources
 - (n) Methods of installing components for mechanical continuous strip weighers:
 - (i) "live" rolls
 - (ii) bearings
 - (iii) links
 - (iv) scale balance and lever mechanism
 - (v) indicating heads and totalizers
 - (vi) load cells
 - (vii) rate recorders
 - (viii) electrical transmission runs
 - (o) Methods of installing components for continuous-strip weighing through the use of radio-isotopes:
 - (i) structural members
 - (ii) fixed traversing units
 - (iii) driving units
 - (iv) signal cables
 - (v) recorders for providing strip, profile, or machine direction weight
 - (vi) panels
 - (vii) others
 - (p) Methods of installing suspended short belt continuous feeders
 - (q) Methods of installing hopper and gate type continuous feeders
 - (r) Type, use, or method of assembly:
 - (i) metal fasteners
 - (ii) pins, dowels, and locking devices
 - (iii) gears
 - (iv) chains and sprockets
 - (v) alignment of links, levers, sprockets
 - (vi) electrical wiring techniques
 - (vii) layout techniques
 - (s) Care and use of ladders and scaffolds
 - (t) Importance of checking completed installation
 - (u) Mathematics:
 - (i) linear measurements for installation and adjustment
 - (ii) properties of triangle and circle
 - (iii) ratio and proportion

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 12: Weight - Force - Load UNIT 2: Continuous Weigh Scales

OPERATIONS	KNOWLEDGE
1. Installing continuous weigh scales (cont'd)	(v) Science: (i) force, mass and weight (ii) levers, mechanical advantage (iii) gears and gear trains (iv) stress and strain (v) basic hydraulics and pneumatics (vi) basic electronics

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 12: Weight - Force - Load UNIT 2: Continuous Weigh Scales

OPERATIONS

KNOWLEDGE

2. Calibrating continuous weigh scales

- (a) Interpretation of drawings and specifications to determine:
 - (i) location
 - (ii) function
 - (iii) structural features
 - (iv) belt or machinery details
- (b) Interpretation of manufacturer's literature to determine:
 - (i) type and principles of operation
 - (ii) readout values, relative or absolute
 - (iii) design ratings
 - (iv) design ambient conditions
 - (v) component details from schematics
 - (vi) recommended adjusting and testing details
 - (vii) accuracy under various load conditions
- (c) Importance of checking conveyor belt details against manufacturer's data:
 - (i) troughing angle
 - (ii) belt length and size
 - (iii) belt speed
 - (iv) conveyor incline
 - (v) nominal and peak loads
- (d) Importance of running conveyor belt until it is limber before calibrating
- (e) Effects on calibration and accuracy of:
 - (i) variation in belt tension and weight
 - (ii) load swings
 - (iii) ambient conditions
- (f) Methods of applying test loads to conveyor belts or some part of scale mechanism for calibrating scale:
 - (i) chains of known weight
 - (ii) carriages of known weight
 - (iii) test weights
- (g) Importance of periodically weighing and measuring test chains
- (h) Procedures for correct centering and holding of test chains on conveyor belts
- (i) Care and storage of test chains
- (j) Use of material weighing techniques for testing conveyor scale accuracy

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 12: Weight - Force - Load

UNIT 2: Continuous Weigh Scales

OPERATIONS	KNOWLEDGE
<hr/>	
2. Calibrating continuous weigh scales (cont'd)	<ul style="list-style-type: none">(k) Importance of test duration time and quantity when making a material weight test(l) Procedures of calibrating conveyor scales:<ul style="list-style-type: none">(i) belt measurement(ii) zero adjustment(iii) test load adjustment(iv) counter reading(v) accuracy determination(m) Importance of the number of test runs to final accuracy values(n) Effects on zero accuracy or setting of intergrators(o) Methods of calibrating electronic or pneumatic recorders or indicators for:<ul style="list-style-type: none">(i) zero(ii) range(iii) linearity(p) Use of test equipment for calibrating electrical or pneumatic components(q) Effects of:<ul style="list-style-type: none">(i) deflection of weigh section idlers(ii) lateral and longitudinal motion of weighing idlers(r) Techniques of product sampling and weighing on precision lab scales to determine accuracy of strip-weighers(s) Use of test sample pieces to check calibration of strip-weighing systems(t) Mathematics:<ul style="list-style-type: none">(i) linear, square, cubic measurement to calculate load(ii) ratio and proportion(iii) per cent(iv) graphs, algebra(u) Science:<ul style="list-style-type: none">(i) department of weights and measures standards(ii) force, mass, weight(iii) levers, mechanical advantage(iv) stress, strain and tension(v) linear and angular velocity(vi) basic electronics, and pneumatics

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 12: Weight - Force - Load

UNIT 2: Continuous Weigh Scales

OPERATIONS

KNOWLEDGE

3. Servicing continuous weigh scales

- (a) Interpretation of drawings and specifications to determine:
 - (i) location
 - (ii) identification and location of service runs
 - (iii) structural details
- (b) Interpretation of manufacturer's literature:
 - (i) type
 - (ii) assembling details
 - (iii) parts identification
 - (iv) lubrication
 - (v) recommended maintenance procedures and periods
- (c) Procedures and requirements for frequent checking after initial installation:
 - (i) logging of date to determine the effects of weather or ambient conditions on balancing and accuracy
 - (ii) balance adjustment
 - (iii) idler alignment checks
 - (iv) chain tests
- (d) Procedures for performing routine periodic checking and methods of correction
- (e) Importance of alignment and balance
- (f) Type and use of lubricants
- (g) Methods of determining need for calibration

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 12: Weight - Force - Load

UNIT 2: Continuous Weigh Scales

OPERATIONS	KNOWLEDGE
3. Servicing continuous weigh scales (cont'd)	<div><ul style="list-style-type: none">(h) Procedures for performing major overhauls:<ul style="list-style-type: none">(i) repairing and cleaning of integrator mechanisms(ii) disassembly of balance mechanisms(iii) repair and replacement of plain and anti-friction bearings, shafts, links, knife edges(iv) removal and cleaning methods for mercury and mercury wells(v) checking electrical servo-motors and switching(vi) checking and replacing components in solid state or electron tube type transducers and amplifiers(vii) checking and replacing parts in pneumatic power cylinders, force balance units, receiving bellows, etc.(i) Type and use of test absorbers for checking radio-isotope belt-conveyor weighers(j) Methods of assembling and adjusting conveyor scales(k) Care, storage and checking of test chains(l) Care and use of:<ul style="list-style-type: none">(i) electrical test equipment(ii) pneumatic test equipment(m) Methods of checking accuracy of speed measuring devices(n) Care and use of hand tachometer and stop watches(o) Methods of checking, repairing and replacing:<ul style="list-style-type: none">(i) pneumatic transmission runs and fittings(ii) electrical transmission runs and terminals(p) Procedures for removing and replacing:<ul style="list-style-type: none">(i) metal fasteners(ii) shaft and plate seals(iii) pins, locking devices, springs(iv) counter mechanisms</div>

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 12: Weight - Force - Load

UNIT 2: Continuous Weigh Scales

OPERATIONS

KNOWLEDGE

3. Servicing continuous weigh scales (cont'd)

- (q) Effects of corrosive industrial atmospheres and protective measures
- (r) Care and use of lifting equipment, ladders, and scaffolds
- (s) Importance of testing after overhauling scales
- (t) Mathematics:
 - (i) linear, square and cubic measurements
 - (ii) ratio and proportion
 - (iii) angular measurements
 - (iv) algebra, simple equations
 - (v) graphs
- (u) Science:
 - (i) levers and mechanical advantage
 - (ii) gears and gear trains
 - (iii) rack and pinion
 - (iv) force, mass and weight
 - (v) elements of electrical circuits
 - (vi) basic pneumatics and electronics
 - (vii) department of weights and measures standards
 - (viii) lubricants and their uses
 - (ix) lubricant deterioration

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 12: Weight - Force - Load

UNIT 3: Force and Load

OPERATIONS	KNOWLEDGE
<hr/>	
1. Installing, calibrating and servicing components	<ul style="list-style-type: none">(a) Interpretation of drawings to determine:<ul style="list-style-type: none">(i) purpose(ii) location and mounting of components(iii) transmission and service requirements(b) Interpretation of manufacturer's literature to determine:<ul style="list-style-type: none">(i) type, model and principle of components operation(ii) recommended installation procedure(iii) calibration procedures and values(iv) recommended maintenance program(v) parts identification(c) Procedures for using inferential methods to obtain force readings from pressure or strain sensitive devices(d) Type, use, function, construction and operating principles of pressure and strain transducers:<ul style="list-style-type: none">(i) pneumatic(ii) hydraulic(iii) electrical(e) Type, use, function, construction and operating principles of receivers:<ul style="list-style-type: none">(i) pneumatic(ii) hydraulic(iii) electrical(f) Methods of installing:<ul style="list-style-type: none">(i) transducers(ii) hydraulic(iii) transmission and service systems(g) Procedures for calibrating system components(h) Use of pressure calibrating and test equipment<ul style="list-style-type: none">(i) primary and secondary standards(ii) shop and field equipment(i) Importance and methods of testing for:<ul style="list-style-type: none">(i) pneumatic and hydraulic leaks(ii) electrical leaks, shorts and open circuits(j) Methods of repairing or replacing parts in system components

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 12: Weight - Force - Load

UNIT 3: Force and Load

OPERATIONS

KNOWLEDGE

1. Installing calibrating and servicing components (cont'd)

- (k) Importance of shielding in some electrical networks
- (l) Methods of applying factors to obtain force or load readings from pressure transmission
- (m) Mathematics:
 - (i) linear measurement for layout
 - (ii) powers, roots, to calculate forces or interpret readings
- (n) Science:
 - (i) shear and strain
 - (ii) elementary hydrostatics
 - (iii) levers, linkages, springs
 - (iv) basic pneumatics
 - (v) basic electricity and electronics

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 13: Time - Motion - Vibration

TABLE OF CONTENTS

UNIT 1: Timers	Page 251
2: Motion Devices	256

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 13: Time - Motion -
Vibration

UNIT 1: Timers

OPERATIONS

KNOWLEDGE

1. Installing timers

- (a) Interpretation of drawings, specifications and manufacturer's manuals to determine:
 - (i) type and **purpose**
 - (ii) application
 - (iii) components
 - (iv) location and mounting
 - (v) service requirements and connections
- (b) Classification of timers:
 - (i) timekeepers
 - (ii) elapsed time keepers
 - (iii) control timers
- (c) Type of timers:
 - (i) mechanical
 - (ii) electric
 - (iii) electronic
 - (iv) thermal
 - (v) pneumatic
 - (vi) hydraulic
 - (vii) magnetic
 - (viii) combinations of (i) to (vii)
- (d) Type and function of timekeepers such as watches, clocks and chronometers
- (e) Type and function of elapsed time-keepers such as:
 - (i) stop watches
 - (ii) recording and indicating chronographs and running time devices
 - (iii) frequency generators and counters
 - (iv) other
- (f) Type and function of control timers such as:
 - (i) time switches
 - (ii) time delay devices
 - (iii) time cycle and time schedule controllers
- (g) Type, function, application and arrangement of timer components
- (h) Type and purpose of timer displays
- (i) Methods of installing timers and **components**
- (j) **Importance of adherence to relevant codes and regulations**

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 13: Time - Motion -
Vibration

UNIT 1: Timers

OPERATIONS

KNOWLEDGE

1. Installing timers (cont'd)

- (k) Procedures for connecting and adjusting drive, regulating, trip and reset mechanisms
- (l) Importance of correct orientation and alignment
- (m) Methods of identifying, connecting and testing electrical conductors
- (n) Methods of installing, connecting and leak testing tubing
- (o) Importance of considering the implications of air and electrical power failure
- (p) Techniques of checking timer installations for correct operation and function
- (q) Type and use of tools and test equipment
- (r) Mathematics -
 - linear measurements for layout
- (s) Science:
 - (i) elementary circuitry
 - (ii) voltmeter, ammeter and ohmmeter
 - (iii) linkages, levers and cams
 - (iv) mechanical drives
 - (v) flow through pipes
 - (vi) air pressure and its measurement

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 13: Time - Motion -
Vibration

UNIT 1: Timers

OPERATIONS

KNOWLEDGE

2. Servicing timers

- (a) Interpretation of drawings and manufacturer's service manuals to determine:
 - (i) application
 - (ii) operating principles
 - (iii) circuit detail
 - (iv) recommended procedures for checking and adjusting
 - (v) suggested routine servicing and repair procedures
 - (vi) spare parts identification
- (b) Type and purpose of timers
- (c) Type and application of timer drivers:
 - (i) electric motors (synchronous, induction and d.c.)
 - (ii) spring motors
 - (iii) air motors and pneumatic arrangements
 - (iv) dashpots and weights
 - (v) thermal elements (bimetal strips)
 - (vi) capacitor charges
 - (vii) oscillators (crystal and tuning fork)
 - (viii) electro-magnets (solenoids and flux decay devices)
 - (ix) other
- (d) Type and purpose of mechanical drive components:
 - (i) gears and pinions
 - (ii) levers and cams
 - (iii) clutches and couplings
 - (iv) brakes
 - (v) other
- (e) Type and function of timer regulating and actuating mechanisms:
 - (i) balance wheels and escapements
 - (ii) pendulums
 - (iii) variable speed drives
 - (iv) adjustable restrictors
 - (v) cams, discs, drums, pins and dogs
 - (vi) links, levers and arms
 - (vii) baffles and interrupters
 - (viii) variable resistances
 - (ix) contacts and switches
 - (x) other

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 13: Time - Motion -
Vibration

UNIT 1: Timers

OPERATIONS	KNOWLEDGE
<hr/>	
2. Servicing timers (cont'd)	<ul style="list-style-type: none">(f) Methods of checking timers for proper operation, functions, and accuracy(g) Type, care and use of secondary time and frequency standards(h) Purpose and methods of adjusting timers(i) Importance of securing adjustments(j) Importance of establishing correct sequencing of functions(k) Methods and requirements for altering time and function sequences(l) Interpretation of timing diagrams(m) Techniques in recognition of timer malfunctions(n) Considerations in locating malfunctions(o) Procedures for testing electrical circuits and components for proper characteristics and performance(p) Care and use of electrical test meters:<ul style="list-style-type: none">(i) V.O.M.'s(ii) V.T.V.M.'s(iii) oscilloscopes(iv) tube checkers(v) stroboscopes(vi) other(q) Methods of inspecting components and parts for wear and cleanliness(r) Methods of repairing and replacing faulty components(s) Procedures, materials and equipment for manufacturing replacement parts(t) Techniques of dismantling, cleaning and assembling components(u) Importance of care, skill and cleanliness in handling delicate mechanisms(v) Methods of setting and checking clearances and tensions(w) Equipment and methods employed in cleaning components and parts(x) Type, application and frequency of lubrication(y) Effects of indiscriminate use of lubricants(z) Care and use of small hand tools and power tools

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 13: Time - Motion -
Vibration

UNIT 1: Timers

OPERATIONS

KNOWLEDGE

2. Servicing timers (cont'd)

(aa) Mathematics:

- (i) linear, angular and metric measurement to determine settings and adjustment
- (ii) graphs to establish timing intervals and sequences
- (iii) ratio and proportion for lever systems and gear train calculations
- (iv) geometry of a circle for setting rotary timing functions

(bb) Science:

- (i) type of lubricants, viscosity ratings and uses
- (ii) heat treatment and surface hardening of steels
- (iii) materials for bearings
- (iv) organic solvents
- (v) systems, units and techniques of measurement
- (vi) thermal expansion and contraction
- (vii) linkages and levers
- (viii) ratchets and cams
- (ix) mechanical drives
- (x) Bernoullis' theorem
- (xi) fits and clearances
- (xii) precision measuring devices
- (xiii) electricity
- (xiv) electronics

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 13: Time - Motion -
Vibration

UNIT 2: Motion Devices

OPERATIONS	KNOWLEDGE
<hr/>	
1. Installing motion measuring	<ul style="list-style-type: none">(a) Interpretation of drawings and manufacturer's literature to determine:<ul style="list-style-type: none">(i) type and purpose(ii) components(iii) location and mounting(iv) service requirements and connections(b) Type of motion measurements (linear and rotational):<ul style="list-style-type: none">(i) displacement(ii) velocity and frequency(iii) acceleration(c) Type of devices (portable and fixed location):<ul style="list-style-type: none">(i) mechanical(ii) pneumatic(iii) electric(iv) electronic(v) magnetic(vi) acoustical(vii) combinations of (i) - (vi)(d) Type and application of displacement measuring devices:<ul style="list-style-type: none">(i) dial test indicators(ii) linear counters(iii) inertia and motion switches(iv) vibroswitches and vibrometers(v) stretch and elongation systems(vi) other(e) Type and application of velocity measuring devices:<ul style="list-style-type: none">(i) tachometers(ii) revolution counters(iii) speed regulators and governors(iv) stroboscopes(v) anemometers(vi) velometers(vii) vibration meters and analysers(viii) frequency meters(ix) other(f) Type and application of acceleration measuring devices:<ul style="list-style-type: none">(i) accelerometers(ii) vibration analysers(iii) other

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 13: Time - Motion -
Vibration

UNIT 2: Motion Devices

OPERATIONS

KNOWLEDGE

1. Installing motion measuring
devices (cont'd)

- (g) Type, purpose and function of major components:
 - (i) pickups and primary measurement devices
 - (ii) readout and display devices
 - (iii) signal transmission and manipulation devices
 - (iv) driving and actuating mechanisms
- (h) Methods of installing and fastening components
- (i) Importance of adherence to relevant codes and regulations
- (j) Environmental considerations:
 - (i) temperature
 - (ii) humidity
 - (iii) corrosive atmosphere
- (k) Considerations when mounting pickups and primary measuring devices:
 - (i) mechanical contact
 - (ii) rigidity of fixtures and brackets
 - (iii) identification of sensitive axis and direction of rotation
 - (iv) accessibility, orientation and position
- (l) Type and use of resonant mountings and damping pads
- (m) Methods of connecting driving and actuating mechanisms:
 - (i) flexible and solid drives
 - (ii) flexible, rigid and slipping clutch couplings
 - (iii) arms, levers, rollers and contacting surfaces
- (n) Procedures for checking and adjusting driving and actuating mechanisms for:
 - (i) alignment
 - (ii) mesh
 - (iii) backlash
 - (iv) tension
- (o) Methods of installing, connecting and testing tubing
- (p) Methods of identifying, connecting and testing electrical conductors

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 13: Time - Motion -
Vibration

UNIT 2: Motion Devices

OPERATIONS	KNOWLEDGE
<hr/>	
1. Installing motion measuring	(q) Purpose and use of conductor shielding (r) Importance of checking for correct power supplies and polarities (s) Procedures for checking installation for correct operation and function (t) Type and use of electrical test meters (u) Care and use of tools and equipment (v) Mathematics: linear and angular measurements for component layout and linkage adjustments (w) Science: (i) mechanical drives (ii) linkages and levers (iii) air pressure and its measurement (iv) elementary circuitry (v) ammeters, voltmeters and ohmmeters

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 13: Time - Motion -
Vibration

UNIT 2: Motion Devices

OPERATIONS

KNOWLEDGE

2. Calibrating motion measuring
devices

- (a) Interpretation of manufacturer's literature and relevant handbooks to determine:
 - (i) function
 - (ii) principle of operation
 - (iii) range and accuracy specifications
 - (iv) recommended calibrating procedures
- (b) Type of calibration checks:
 - (i) shop
 - (ii) field
- (c) Methods and purpose of calibration
- (d) Type, function and use of secondary calibrating standards:
 - (i) precision linear measuring devices
 - (ii) precision weights
 - (iii) stroboscopes
 - (iv) frequency generators
 - (v) manometers
 - (vi) test pressure gauges
 - (vii) signal generators
 - (viii) V.T.V.M.'s
 - (ix) oscilloscopes
 - (x) chronometers and stop watches
 - (xi) test primary measuring devices
- (e) Type, function and use of motion generating equipment:
 - (i) shaker tables and stationary references
 - (ii) centrifuges
 - (iii) synchronous and variable speed motors
 - (iv) adjustable drives
 - (v) other
- (f) Considerations when contemplating shop calibration
- (g) Methods of securing and connecting primary measuring devices to generating and drive equipment
- (h) Methods of connecting power, air and calibrating standards to devices under test
- (i) Procedures for selecting and adjusting controls

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 13: Time - Motion -
Vibration

UNIT 2: Motion Devices

OPERATIONS	KNOWLEDGE
2. Calibrating motion measuring devices (cont'd)	<ul style="list-style-type: none"> (j) Procedures for energizing and operating generating equipment (k) Techniques of applying and interpreting calibrating standards (l) Techniques of interpreting output information and characteristics of devices under test (m) Methods of adjusting for: <ul style="list-style-type: none"> (i) zero (ii) range (iii) linearity (iv) sensitivity (v) damping (n) Procedures and considerations when field calibrating (o) Type and use of portable calibrating standards (p) Techniques of applying time, displacement and velocity calculations (q) Methods of converting units of measurement (r) Mathematics: <ul style="list-style-type: none"> (i) English and metric measure, percentage, powers and roots to determine and convert units of measurement (ii) ratio, proportion and simple equations to calculate calibrating adjustments (iii) algebraic equations and formulae to calculate motions (s) Science: <ul style="list-style-type: none"> (i) pneumatics (ii) systems, units and techniques of measurement (iii) velocity and acceleration (iv) centrifugal force (v) mass, weight and inertia (vi) harmonics (vii) electricity (viii) electronics

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 13: Time - Motion -
Vibration

UNIT 2: Motion Devices

OPERATIONS

KNOWLEDGE

3. Servicing motion measuring
devices

- (a) Interpretation of schematic diagrams and manufacturer's manuals to determine:
 - (i) application
 - (ii) operating principles
 - (iii) component construction
 - (iv) circuit detail
 - (v) recommended servicing procedures
 - (vi) spare parts identification
- (b) Type, purpose and characteristics of primary measuring devices:
 - (i) generators, AC and DC
 - (ii) tachometers - centrifugal weight, fluid displacement, chronometric, eddy current, impulse, resonant need, and photo-electric
 - (iii) vibration pick-ups - piezoelectric, magnetic, inductive, capacitive, and resistive
 - (iv) mass and spring, vane and tunnel and others
- (c) Type and purpose of electronic circuits and components:
 - (i) amplifiers and oscillators
 - (ii) power supplies and rectifiers
 - (iii) filters
 - (iv) integrators
 - (v) bridges and potentiometers
 - (vi) other
- (d) Type and purpose of readout devices and displays:
 - (i) counters
 - (ii) indicating and recording voltmeters, ammeters and ohmmeters
 - (iii) miscellaneous calibrated scale and pointer mechanisms
 - (iv) light beams and optics
 - (v) magnetic tape recorders
 - (vi) oscilloscopes and oscillographs
 - (vii) earphones
 - (viii) audible and visual alarms
 - (ix) other
- (e) Service considerations

. MEASUREMENT .

BLOCK 13: Time - Motion -
Vibration

UNIT 2: Motion Devices

OPERATIONS	KNOWLEDGE
3. Servicing motion measuring devices (cont'd)	<ul style="list-style-type: none"> (f) Importance of frequent casual inspections of devices and components for: <ul style="list-style-type: none"> (i) visual damage and wear (ii) security of mounting (iii) security of electrical and mechanical connections (iv) proper functioning (v) friction, noisy bearings and drives (g) Type and frequency of lubrication of drives, actuating mechanisms and bearings (h) Methods of applying lubricants (i) Techniques of locating sources of equipment failure or malfunction (j) Methods of testing components by substitution and simulation of signals (k) Procedures for measuring pick-up and primary device output signals (l) Methods of removing and checking electronic component performance (m) Techniques of measuring and adjusting electronic circuit parameters (n) Type and use of electrical test meters and equipment: <ul style="list-style-type: none"> (i) V.O.M.'s and V.T.V.M.'s (ii) oscilloscopes (iii) tube testers (iv) impedance bridges and decade simulators (R.C. and L.) (v) signal generators (vi) other (o) Methods, tools and materials for cleaning, gapping and adjusting tension of electrical contacting surfaces: <ul style="list-style-type: none"> (i) commutators and brushes (ii) slidewires and wipers (iii) contacts (p) Methods of testing and replacing dry cells (q) Procedures for overhauling mechanical devices

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 13: Time - Motion -
Vibration

UNIT 2: Motion Devices

OPERATIONS

KNOWLEDGE

3. Servicing motion measuring
devices (cont'd)

- (r) Methods of repairing and replacing worn or broken parts:
 - (i) pivots and bearings
 - (ii) shafts and sleeves
 - (iii) racks, pinions and gears
 - (iv) cable and worm drives
 - (v) linkages and levers
 - (vi) springs
 - (vii) other
- (s) Methods and materials for cleaning parts
- (t) Type, use and method of replacing gaskets and seals
- (u) Importance of checking and adjusting overhauled devices for correct functioning
- (v) Methods of leak testing, repairing and replacing tubing and connections
- (w) Mathematics:
 - (i) linear measurement for setting gaps, clearances and tension
 - (ii) ratio and proportion to determine adjustments and replacements of linkages, gears and other
 - (iii) graphs and algebraic equations to calculate electronic component performance and characteristics
- (x) Science:
 - (i) fits and clearances
 - (ii) precision measuring devices
 - (iii) Bernoullis' theorem
 - (iv) gear, belt, chain, cable and worm drives
 - (v) linkages, levers, ratchets and cams
 - (vi) mechanical advantage
 - (vii) lubricants and their uses
 - (viii) organic solvents and uses
 - (ix) pneumatics
 - (x) electricity and electronics

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE
 . MEASUREMENT .

BLOCK 14: Dimensional

TABLE OF CONTENTS

UNIT 1: Position	Page 265
2: Thickness	268
3: Area	270
4: Volume	271

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 14: Dimensional

UNIT 1: Position

OPERATIONS

KNOWLEDGE

1. Installing components

- (a) Interpretation of drawings to determine:
 - (i) purpose
 - (ii) location
 - (iii) mounting details
 - (iv) transmission details
 - (v) services required
- (b) Interpretation of manufacturer's literature to determine:
 - (i) type and model
 - (ii) angular or linear range
 - (iii) mounting recommendations
 - (iv) service and signal connection details
- (c) Type, use, function and construction details of linear and angular pneumatic position transmitters
- (d) Use of valve positioners as position transmitters
- (e) Type, use, function and construction details of electric position transmitters:
 - (i) limit switches
 - (ii) slidewires
 - (iii) synchromotors
 - (iv) photo-tubes
 - (v) others
- (f) Use of standard pressure indicators and recorders as receivers for pneumatic position transmission
- (g) Methods of receiving electrical transmission of position:
 - (i) lights
 - (ii) simple ammeters or voltmeters
 - (iii) bridge instruments
 - (iv) others
- (h) Type, size, and material of component parts of transmission systems:
 - (i) electrical
 - (ii) pneumatic
- (i) Type, size and method of providing or installing electrical power supplies and small pressure regulators
- (j) Methods of installing transmission runs

. MEASUREMENT .

BLOCK 14: Diminsional

UNIT 1: Position

OPERATIONS	KNOWLEDGE
<hr/>	
1. Installing components (cont'd)	(k) Procedures for field mounting transmitters and panel mounting receivers (l) Methods of suppressing zero signal values or modifying spans (m) Importance of testing the completed installation (n) Mathematics: (i) linear and angular measurement for layout (ii) roots, ratio and proportion, simple equations to understand theory (o) Science: (i) levers, linkages, cams and gears (ii) basic pneumatics and electricity

. MEASUREMENT .

BLOCK 14: Dimensional

UNIT 1: Position

OPERATIONS

KNOWLEDGE

2. Calibrating and servicing

- (a) Interpretation of manufacturer's literature to determine:
 - (i) type and mode of components
 - (ii) assembly details of components
 - (iii) range and span limits
 - (iv) recommended calibration procedures
 - (v) maintenance recommendations
 - (vi) parts identification
 - (vii) services required
- (b) Methods of calibrating components for:
 - (i) zero
 - (ii) range
 - (iii) linearity
- (c) Procedures for providing:
 - (i) suppression
 - (ii) characterized signals
- (d) Effects of transmission distance on signal values
- (e) Use of calibrating and test equipment
- (f) Importance of checking for leaks in pneumatic systems
- (g) Effects and methods of correcting in electrical systems for:
 - (i) leakage paths
 - (ii) high resistance
 - (iii) shorts
- (h) Procedures for servicing pneumatic or electronic amplifiers
- (i) Methods of replacing or repairing indicator or recorder mechanisms
- (j) Methods of protecting components against:
 - (i) plant atmospheres
 - (ii) vibration
- (k) Mathematics:
 - (i) linear and angular measurements for setting linkage systems
 - (ii) ratio and proportion, simple equations, and percent for determining calibration values and results
- (l) Science:
 - (i) levers, linkages, cams and gears
 - (ii) basic pneumatic and electricity

. MEASUREMENT .

BLOCK 14: Dimensional

UNIT 2: Thickness

OPERATIONS	KNOWLEDGE
1. Installing, calibrating and servicing thickness gauges	<ul style="list-style-type: none"> (a) Interpretation of drawings to determine: <ul style="list-style-type: none"> (i) location (ii) mounting (iii) services required and connection details (b) Interpretation of manufacturer's literature to determine: <ul style="list-style-type: none"> (i) details of construction (ii) recommended installation procedure (iii) range, span and accuracy limits (iv) adjustment details (v) recommended maintenance and operating procedures (vi) parts identification (c) Type, principle, range and method of installing: <ul style="list-style-type: none"> (i) mechanical caliper (ii) combination mechanical and electrical caliper (iii) electro-magnetic (non-contact) (iv) radio-active absorption (non contact) (v) ultra-sonic (vi) others (d) Comparison of the machine (continuous) and off the machine (product sample) gauges (e) Type, use, construction and installation of automatic scanning systems for gauging wide strips (f) Use of precision samples or test pieces for calibrating (g) Comparison of absolute and relative values and methods of calibrating (h) Advantages, disadvantages and use of instruments requiring both sides of product compared to those requiring one side (i) Care in handling radio-active sources (j) Type, use, installation and calibration of display instruments: <ul style="list-style-type: none"> (i) counters (ii) indicators (iii) recorders

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 14: Dimensional

UNIT 2: Thickness

OPERATIONS

KNOWLEDGE

1. Installing, calibrating
and servicing thickness
gauges (cont'd)

- (k) Methods used to develop signals:
 - (i) electrical sensing of position
 - (ii) electronic bridges
 - (iii) mechanical
- (l) Methods used to test, repair or
replace components in electronic
circuits
- (m) Type, use, and principle of electrical
and electronic test equipment
- (n) Mathematics:
 - (i) linear and angular measurement
for layout
 - (ii) powers, roots, logarithms, ratio
and proportion for reading
instruments and understanding
theory
- (o) Science:
 - (i) gear trains
 - (ii) basic electricity and electronics
 - (iii) radioactivity
 - (iv) characteristics of ultra-sonic
waves

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 14: Dimensional

UNIT 3: Area

OPERATIONS	KNOWLEDGE
<hr/>	
1. Using planimeters	(a) Interpretation of manufacturer's literature to determine: (i) type (ii) specific procedure for using (iii) factors (b) Type, factors, and method of using in flow chart computations: (i) square root or uniform (ii) circular or strip charts (c) Importance of establishing correct conversion factors (d) Mathematics - linear, square and cubic measurement to check factors (e) Science - levers, linkages, gears and cams

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 14: Dimensional

UNIT 4: Volume

OPERATIONS

KNOWLEDGE

1. Installing, calibrating
and servicing components

- (a) Interpretation of drawings to determine:
 - (i) purpose
 - (ii) location
 - (iii) installation details of components
 - (iv) installation details of transmission and service systems
- (b) Interpretation of manufacturer's literature to determine:
 - (i) type, model and function of components
 - (ii) installation recommendations
 - (iii) adjustments and values of calibration of components
 - (iv) maintenance recommendations
- (c) Procedures for obtaining volume measurement using inferential methods on vessels such as:
 - (i) pneumatic and electrical head meters
 - (ii) pneumatic and electrical level meters
 - (iii) pneumatic, hydraulic and electrical load cells
- (d) Use of standard flowmeter systems for volume measurement:
 - (i) pneumatic
 - (ii) electrical
 - (iii) mechanical
- (e) Type, use and interpretation of factors or direct reading scales and charts to obtain volume units from standard measurement systems:
 - (i) head
 - (ii) level
 - (iii) weight
 - (iv) flow
- (f) Type, use and methods of installing primary elements:
 - (i) bubble tubes
 - (ii) diaphragm transmitters
 - (iii) load cells
 - (iv) others

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 14: Dimensional

UNIT 4: Volume

OPERATIONS	KNOWLEDGE
<hr/>	
1. Installing, calibrating and servicing components	<ul style="list-style-type: none">(a) Interpretation of drawings to determine:<ul style="list-style-type: none">(i) purpose(ii) location(iii) installation details of components(iv) installation details of transmission and service systems(b) Interpretation of manufacturer's literature to determine:<ul style="list-style-type: none">(i) type, model and function of components(ii) installation recommendations(iii) adjustments and values of calibration of components(iv) maintenance recommendations(c) Procedures for obtaining volume measurement using inferential methods on vessels such as:<ul style="list-style-type: none">(i) pneumatic and electrical head meters(ii) pneumatic and electrical level meters(iii) pneumatic, hydraulic and electrical load cells(d) Use of standard flowmeter systems for volume measurement:<ul style="list-style-type: none">(i) pneumatic(ii) electrical(iii) mechanical(e) Type, use and interpretation of factors or direct reading scales and charts to obtain volume units from standard measurement systems:<ul style="list-style-type: none">(i) head(ii) level(iii) weight(iv) flow(f) Type, use and methods of installing primary elements:<ul style="list-style-type: none">(i) bubble tubes(ii) diaphragm transmitters(iii) load cells(iv) others

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 14: Dimensional

UNIT 4: Volume

OPERATIONS

KNOWLEDGE

1. Installing, calibrating
and servicing components
(cont'd)

- (g) Methods of installing:
 - (i) tubing runs
 - (ii) electrical transmission lines
 - (iii) raceways and conduits
- (h) Procedures for installing field and panel mounted display instruments
- (i) Methods of calibrating standard pneumatic and electrical instruments used for volume measurement
- (j) Use of pneumatic and electrical calibrating and test instruments
- (k) Procedures for testing and troubleshooting complete measurement system
- (l) Methods of maintaining pneumatic and electrical components used for volume measurement:
 - (i) transmitters
 - (ii) receivers
 - (iii) display units
 - (iv) others
- (m) Mathematics:
 - (i) linear measurement for layout
 - (ii) square and cubic measurement for calculating linear to volumetric relations on vessels
- (n) Science:
 - (i) pressure due to head
 - (ii) flow through pipes
 - (iii) density - specific gravity
 - (iv) basic pneumatics
 - (v) basic electricity and electronics

BLOCK 15: Counters

TABLE OF CONTENTS

UNIT 1: Mechanical	Page 275
2: Electrical	278

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 15: Counters

UNIT 1: Mechanical

OPERATIONS

KNOWLEDGE

1. Installing mechanical counters

- (a) Interpretation of drawings to determine:
 - (i) purpose of installation
 - (ii) operating conditions
 - (iii) location
 - (iv) type, size and model of counter
 - (v) type of mounting
- (b) Type, size and function of mechanical counters:
 - (i) linear
 - (ii) reciprocating
 - (iii) revolutions
 - (iv) totalising
 - (v) predetermining
 - (vi) reset
- (c) Type, purpose and function of reset and trip mechanisms
- (d) Type, purpose and correct function of counter gear mechanisms
- (e) Type and function if display:
 - (i) digital
 - (ii) dial
- (f) Methods of installing counters
- (g) Importance of correct alignment
- (h) Methods of connecting counters to actuating mechanisms:
 - (i) couplings
 - (ii) shafts
- (i) Type, application and method of installing drive shafts:
 - (i) solid
 - (ii) flexible
- (j) Type, purpose, application and method of fastening couplings:
 - (i) flexible
 - (ii) rigid
 - (iii) bellows
 - (iv) magnetic
 - (v) clutch
- (k) Procedure for wiring trip and reset circuits

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 15: Counters

UNIT 1: Mechanical

OPERATIONS	KNOWLEDGE
<hr/>	
1. Installing mechanical counters (cont'd)	(l) Type, purpose and method of connecting of alarm components (i) horns, sirens, bells (ii) relays (iii) visual displays (m) Importance of availability of correct power supply: (i) voltage (ii) frequency (n) Importance of checking counters for correct operation and function (o) Mathematics - linear measurement for layout (p) Science: (i) gear trains (ii) linkages (iii) voltmeter, ammeter, ohmmeter

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 15: Counters

UNIT 1: Mechanical

OPERATIONS

KNOWLEDGE

2. Servicing and repairing mechanical counters

- (a) Interpretation of manufacturer's service manuals
- (b) Considerations regarding operating conditions:
 - (i) temperature and humidity
 - (ii) corrosive vapours
- (c) Importance of inspection for correct function
- (d) Methods and frequency of lubrication
- (e) Effect of over-lubrication
- (f) Methods of dismantling and replacement of counter components:
 - (i) gears
 - (ii) switches
 - (iii) trip mechanism
 - (iv) display components
- (g) Methods of inspection for wear
- (h) Methods of replacing bearings:
 - (i) ball
 - (ii) roll
 - (iii) sleeve
 - (iv) others
- (i) Methods of replacing couplings and shafts
- (j) Methods of cleaning components with solvents:
 - (i) chemical
 - (ii) ultrasonic
- (k) Methods of reassembly
- (l) Importance of checking for cleanliness and correct function
- (m) Mathematics -
 - calculations to determine gear ratios
- (n) Science:
 - (i) mechanical advantage
 - (ii) gear trains
 - (iii) mechanisms

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 15: Counters

UNIT 2: Electrical

OPERATIONS	KNOWLEDGE
<hr/>	
1. Installing electrical pick-ups	<ul style="list-style-type: none">(a) Interpretation of drawings to determine:<ul style="list-style-type: none">(i) type of pick-up(ii) type of information mechanism(iii) location(b) Type, purpose and application of pick-ups:<ul style="list-style-type: none">(i) micro-switch(ii) electromagnetic(iii) photo-electric(iv) ultrasonic(v) infra-red(vi) nuclear radiation(vii) capacitive(c) Type and function of information devices:<ul style="list-style-type: none">(i) gears(ii) slotted discs(iii) others(d) Service conditions and considerations:<ul style="list-style-type: none">(i) ambient light(ii) vibration, noise level(iii) dust, vapours, smoke(iv) temperature, humidity(v) electro-magnetic field(e) Methods of mounting information devices and pick-ups(f) Procedures for aligning pick-ups with information devices(g) Effect of misalignment on the pick-up signal(h) Type, purpose and method of installing fittings and connectors(i) Methods of wiring pick-ups to counters(j) Technique of shielding and grounding(k) Effect of stray signals on the pick-up signal(l) Methods of wiring electrical components(m) Electrical power requirements:<ul style="list-style-type: none">(i) power supply(ii) voltage, frequency(iii) conductor sizes, connectors(iv) disconnect switches(n) Mathematics -<ul style="list-style-type: none">linear measurements for layout purposes

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 15: Counters

UNIT 2: Electrical

OPERATIONS

KNOWLEDGE

1. Installing electrical
pick-ups (cont'd)

(o) Science:

- (i) principles of electricity
- (ii) optics
- (iii) black body radiation
- (iv) E.M.F. generation
- (v) phase, frequency
- (vi) propagation of sound

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 15: Counters

UNIT 2: Electrical

OPERATIONS	KNOWLEDGE
<hr/>	
2. Installing electrical counters	<ul style="list-style-type: none">(a) Interpretation of drawings and specifications to determine:<ul style="list-style-type: none">(i) type of counter(ii) location(iii) type of mounting(b) Type, purpose and principle of operation of electrical counters:<ul style="list-style-type: none">(i) electronic(ii) electro-magnetic(c) Interpretation of manufacturer's instruction manuals to determine:<ul style="list-style-type: none">(i) external wiring connections(ii) power requirements(iii) type of display(iv) dimensions(d) Type of display:<ul style="list-style-type: none">(i) digital in-line(ii) column readout(iii) decatron type(e) Service conditions:<ul style="list-style-type: none">(i) temperature and humidity(ii) vibration, noise level(iii) vapours(iv) lighting(f) Methods of mounting counters:<ul style="list-style-type: none">(i) panel(ii) surface(iii) portable(g) Procedures for panel cutting, drilling and finishing(h) Type, purpose and use of fittings and connectors(i) Methods and materials used for fabrication of brackets and supports(j) Techniques of soldering and brazing(k) Methods of eliminating effect of vibration by:<ul style="list-style-type: none">(i) springs(ii) shock pads(l) Importance of accessibility for servicing and maintenance(m) Interpretation of electrical and instrumentation standards and symbols

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 15: Counters

UNIT 2: Electrical

OPERATIONS

KNOWLEDGE

2. Installing electrical counters (cont'd)

- (n) Methods of connecting pick-up wires to counter
- (o) Importance and effect of shielding
- (p) Requirements for connection of electrical power supply:
 - (i) power
 - (ii) voltage, frequency
 - (iii) conductor sizes, connectors
 - (iv) disconnect switches
- (q) Type, size and application of electrical conductors and connectors
- (r) Methods and importance of purging panels in explosive and corrosive atmospheres
- (s) Techniques of testing electrical circuits for:
 - (i) continuity
 - (ii) insulation
- (t) Type, function and application of electrical test instruments:
 - (i) multimeter
 - (ii) megger
- (u) Methods and importance of testing counter installation for correct function
- (v) Mathematics -
 - linear measurements for layout
- (w) Science:
 - (i) basic electricity
 - (ii) voltmeter, ammeter, ohmmeter

BLOCK 15: Counters

UNIT 2: Electrical

OPERATIONS	KNOWLEDGE
3. Repairing and servicing electrical pick-ups	<ul style="list-style-type: none"> (a) Interpretation of manufacturer's instruction manuals (b) Operating conditions: <ul style="list-style-type: none"> (i) ambient light (ii) vibration, noise level (iii) dust and vapours (iv) temperatures (v) electromagnetic field (c) Procedures for isolating pick-ups (d) Methods of checking and correcting alignment of: <ul style="list-style-type: none"> (i) pick-ups (ii) information devices (e) Procedures for checking electrical signals from pick-ups (f) Type and use of portable test instruments: <ul style="list-style-type: none"> (i) oscilloscope (ii) multimeter (g) Techniques of cleaning pick-ups (h) Methods of lubrication (i) Type of lubricants (j) Methods of protecting pick-up components from contamination and interference (k) Type of antistatic materials (l) Mathematics: <ul style="list-style-type: none"> (i) roots, powers (ii) basic trigonometric functions (m) Science: <ul style="list-style-type: none"> (i) static electricity (ii) wave forms (sine waves) and harmonics (iii) optics (iv) propagation of energy (v) gears and mechanisms (vi) lubricants and their uses

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 15: Counters

UNIT 2: Electrical

OPERATIONS

KNOWLEDGE

4. Servicing and repairing electrical counters

- (a) Interpretation of manufacturer's instruction manuals and electrical circuits to determine servicing procedures
- (b) Operating conditions:
 - (i) general purpose area
 - (ii) explosion proof area
- (c) Procedures for isolating counters from electrical sources
- (d) Methods of cleaning counters and counter components
- (e) Methods of testing counters for correct operation using:
 - (i) standard external signal
 - (ii) standard comparison counter
- (f) Type, method and use of test instruments:
 - (i) oscilloscope
 - (ii) tube and transistor testers
 - (iii) multimeter
- (g) Techniques of troubleshooting counter circuits for faulty performance
- (h) Techniques of replacing faulty components
- (i) Methods of adjusting counters for correct sensitivity and time of display
- (j) Procedures for testing counters for correct function and operation
- (k) Mathematics:
 - (i) graph of sine curve
 - (ii) binary-decimal conversion
- (l) Science:
 - (i) solvents
 - (ii) voltmeter-ammeter-ohmmeter
 - (iii) vacuum tubes and transistors
 - (iv) cathode Ray Tubes

. MEASUREMENT .

BLOCK 15: Counters

UNIT 2: Electrical

OPERATIONS	KNOWLEDGE
5. Calibrating electronic counters	<ul style="list-style-type: none"> (a) Interpretation of manufacturer's service manuals to determine calibration procedures (b) Methods of testing electronic counters for: <ul style="list-style-type: none"> (i) pulse duration (ii) display function (iii) count (c) Procedures for checking frequency of oscillators: <ul style="list-style-type: none"> (i) R-C couples and L-C coupled types (ii) crystal controlled oscillators (d) Type and function of time base generators: <ul style="list-style-type: none"> (i) line frequency controlled (ii) crystal controlled (e) Type, function and use of test equipment: <ul style="list-style-type: none"> (i) oscilloscope (ii) beat frequency oscillator (iii) frequency standard (f) Methods of checking crystal oscillators using: <ul style="list-style-type: none"> (i) external frequency standard (ii) external frequency counter (g) Techniques of adjusting crystal oscillators (h) Importance of checking counters for correct function and performance (i) Mathematics - <ul style="list-style-type: none"> decimal-binary relationship for counters (j) Science: <ul style="list-style-type: none"> (i) basic electronics (ii) AC-DC amplifiers (iii) pulse circuits (iv) oscillators (v) tubes and transistors (vi) voltmeter-ammeter-ohmmeter

BLOCK 16: Analytical Instruments

TABLE OF CONTENTS

UNIT 1:	Thermal Conductivity and Catalytic Combustion	Page 286
2:	Paramagnetic	292
3:	Infra-red and Ultraviolet Analysing Systems	298
4:	Mass Spectrometers	305
5:	Gas Chromatography	313
6:	Refractometry	323
7:	Moisture	328
8:	Emission Spectroscopy	335
9:	X-Ray	342
10:	Nuclear Magnetic Resonance Spectrometry	350
11:	Ionization	357
12:	Colorimetry	364
13:	pH and Redox	370
14:	Electrical Conductivity and Dielectric Constant	378
15:	Reaction Product	385
16:	Polarography	392

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 16: Analytical Instruments

UNIT 1: Thermal Conductivity and Catalytic Combustion

OPERATIONS	KNOWLEDGE
<hr/>	
1. Installing thermal conductivity and catalytic combustion systems	<ul style="list-style-type: none">(a) Interpretation of drawings, specifications and manufacturer's manuals to determine:<ul style="list-style-type: none">(i) type and application(ii) components(iii) location and mounting(iv) electrical circuitry and power requirements(v) tube and pipe layouts(vi) air, water, steam and other service requirements(b) Importance of adherence to relevant codes and regulations(c) Purpose of measuring systems(d) Type and purpose of components used in:<ul style="list-style-type: none">(i) sample, comparison, conditioning, vent and purge systems(ii) analysing assemblies(iii) display devices(e) Methods of installing components(f) Considerations when mounting components for:<ul style="list-style-type: none">(i) accessibility(ii) orientation(g) Effects of extremes in ambient temperature and pressure upon analyzing system measurement accuracy(h) Methods of installing, connecting and leak testing plastic, metal and glass tubing and pipe(i) Importance of avoiding low spots and condensate traps when installing sample lines(j) Advantages of short sample runs and effect on speed of response(k) Importance of proper positioning of probes to ensure representative sampling(l) Procedures for identifying, testing and connecting electrical conductors(m) Importance of establishing suitable power supply requirements(n) Care and use of electrical test meters(o) Procedures for checking system and preparing for service

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 1: Thermal Conductivity and Catalytic Combustion

OPERATIONS

KNOWLEDGE

- | | |
|--|--|
| 1. Installing thermal conductivity and catalytic combustion systems (cont'd) | (p) Methods and materials used for filling miscellaneous sample purification and conditioning assemblies |
| | (q) Techniques of adjusting flow, pressure and temperature regulators |
| | (r) Care and use of tools and equipment |
| | (s) Mathematics -
linear measurement for layout |
| | (t) Science: |
| | (i) air pressure and measurement |
| | (ii) heat transfer and measurement |
| | (iii) Bernoullis' theorem |
| | (iv) systems, units and techniques of measurement |
| | (v) conductors and insulators |
| | (vi) elementary circuitry |
| | (vii) amperage, voltage and resistance |
| | (viii) voltmeter, ammeter and ohmmeter |
| | (ix) pressure due to head |
| | (x) flow through pipes |
| | (xi) venturis and aspirators |

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 16: Analytical Instruments

UNIT 1: Thermal Conductivity and Catalytic Combustion

OPERATIONS	KNOWLEDGE
<hr/>	
2. Calibrating thermal conductivity and catalytic combustion systems	<ul style="list-style-type: none">(a) Interpretation of manufacturer's literature to determine:<ul style="list-style-type: none">(i) operating principles(ii) application data(iii) recommended calibrating procedures(iv) accuracy standards(b) Method and purpose of calibration(c) Type and use of calibrating standards and equipment:<ul style="list-style-type: none">(i) calibrating gases(ii) resistance bridges and decade simulators(iii) check resistors(iv) portable potentiometers(d) Methods of preparing and storing calibrating gases(e) Procedures for connecting and applying calibrating standards(f) Importance of maintaining uniform temperature, flow and pressure conditions when calibrating(g) Techniques of adjusting zero, range, linearity and sensitivity(h) Methods of interpreting data readout(i) Care and use of calibrating standards and tools(j) Mathematics:<ul style="list-style-type: none">(i) volumetric calculations for preparation of standard gas samples(ii) algebraic formulae to calculate standard gas samples(iii) percentage to enable interpretation of readout devices(iv) interpretation of graphs to determine calibrating data(k) Science:<ul style="list-style-type: none">(i) heat transfer and measurement(ii) percentage composition from formula(iii) preparation, properties, storage and use of gases(iv) combustion(v) gas laws(vi) molecular weight of gases(vii) scientific measurement(viii) electricity(ix) electronics

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 1: Thermal Conductivity and Catalytic Combustion

OPERATIONS

KNOWLEDGE

3. Servicing thermal conductivity and catalytic combustion systems

- (a) Interpretation of manufacturer's manuals, circuit drawings and relevant handbooks to determine:
 - (i) type, purpose and function
 - (ii) component construction
 - (iii) significant electrical circuit check points and values
 - (iv) suggested repair and routine maintenance procedures
 - (v) recommended spare parts
- (b) Methods of testing, removing, repairing and replacing system components
- (c) Purpose and function of sample system components:
 - (i) filters, purifiers and traps
 - (ii) driers and saturators
 - (iii) pumps, aspirators and injectors
 - (iv) valves, powered rotary selection valves and restrictors
 - (v) flow, pressure and temperature indicators, glass tubing and pipe
 - (vi) other
- (d) Procedures for leak testing sample systems
- (e) Effects to measurement of leaking sample systems where sample is being introduced by applied suction
- (f) Methods of compensating for and removing moisture in gas samples
- (g) Procedures and materials for cleaning and replenishing filters, driers, saturators and miscellaneous purifying assemblies
- (h) Importance of maintaining adequate lubrication of pumps and drivers

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 1: Thermal Conductivity and Catalytic Combustion

OPERATIONS

KNOWLEDGE

3. Servicing thermal conductivity and catalytic combustion systems (cont'd)

- (i) Type and purpose of analyser and display components:
 - (i) sampling and reference detector cells, hot wires, catalytic filaments and thermocouples
 - (ii) self-balancing Wheatstone bridges, potentiometers, voltmeters and ammeters
 - (iii) heaters and thermostats
 - (iv) power supplies and rectifiers
 - (v) amplifiers
 - (vi) servomechanisms and motors
 - (vii) relays, switches and potentiometers
 - (viii) miscellaneous circuit components
 - (ix) audible and visible alarms
 - (x) mechanical drives
 - (xi) other
- (j) Detector cell servicing consideration:
 - (i) number of cells used
 - (ii) importance of using matched cells when replacing
 - (iii) effects of "poisoned" cells and methods of rejuvenating
 - (iv) symptoms of contaminated cells and methods and materials used for cleaning
 - (v) current and temperature ratings of cell elements
- (k) Methods of sample introduction to the cell
- (l) Importance of sample and reference gas flow rate and temperature and techniques of determining and adjusting
- (m) Procedures for checking electrical components and circuit values
- (n) Care and use of electrical test instruments
- (o) Methods of cleaning slidewires and electrical contacts
- (p) Methods of checking for wear, cleaning and lubricating mechanical drives, pivots and bearings

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 1: Thermal Conductivity and Catalytic Combustion

OPERATIONS

KNOWLEDGE

3. Servicing thermal conductivity and catalytic combustion systems (cont'd)

- (q) Techniques of zeroing and checking system for proper functioning
- (r) Interpretation of display functions
- (s) Care, use and storage of tools and equipment
- (t) Mathematics -
 - graphs, algebraic equations and formulae for determining electrical measurements, and electrical component performance characteristics
- (u) Science:
 - (i) characteristics and properties of gases and mixtures
 - (ii) gas laws
 - (iii) type, viscosities and use of lubricants
 - (iv) organic solvents and acids
 - (v) systems, units and techniques of measurement
 - (vi) heat transfer
 - (vii) electricity
 - (viii) electronics
 - (ix) linkages, levers, drives, ratchets and cams
 - (x) pressure due to head, flow through pipes and Bernoulli's theorem

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 2: Paramagnetic

OPERATIONS	KNOWLEDGE
1. Installing paramagnetic analysing systems	<ul style="list-style-type: none"> (a) Interpretation of drawings, specifications and manufacturer's literature to determine: <ul style="list-style-type: none"> (i) type, purpose and application (ii) components (iii) location and mounting (iv) pipe and tube layouts and service requirements (v) electrical connections and power requirements (b) Importance of adherence to relevant codes and regulations (c) Type of systems: <ul style="list-style-type: none"> (i) laboratory (ii) portable (iii) continuous stream analysis (d) Type and purpose of components (e) Methods of installing components (f) Considerations when mounting components for: <ul style="list-style-type: none"> (i) orientation (ii) accessibility (iii) rigidity (g) Importance of avoiding locations where extremes of temperature, vibration and moisture might exist (h) Methods of identifying, testing matching and connecting electrical conductors (i) Procedures and materials for establishing suitability of power supply (j) Type, care and use of electrical test instruments (k) Importance of separate cable and conduit run for analyser signal conductors (l) Procedures for installing and connecting sample, purge and vent system tube and pipe (m) Methods and materials for flushing and leak testing tubing and pipe (n) Effects of long sample lines to measurement response (o) Procedures for checking installation and placing system in operation

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 2: Paramagnetic

OPERATIONS

KNOWLEDGE

1. Installing paramagnetic
analysing systems (cont'd)

- (p) Importance of removing all shipping blocks and allowing adequate warm-up period
- (q) Results of allowing tools, test meters or wrist watches to come into close contact with analyser magnets
- (r) Methods of checking and setting miscellaneous flow, temperature and zero adjustments
- (s) Techniques of interpreting readout and display devices
- (t) Type, care and use of tools and equipment
- (u) Mathematics -
 linear measurement for layout
- (v) Science:
 - (i) units of measurement
 - (ii) heat transfer
 - (iii) temperature scales
 - (iv) flow through pipes
 - (v) magnetism
 - (vi) conductors and insulators
 - (vii) elementary circuitry
 - (viii) voltmeter, ammeter and ohmmeter
 - (ix) A.C. and D.C.

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 2: Paramagnetic

OPERATIONS	KNOWLEDGE
2. Calibrating paramagnetic systems	<ul style="list-style-type: none"> (a) Interpretation of manufacturer's literature to determine: <ul style="list-style-type: none"> (i) type and principle of operation (ii) application (iii) range and units of measurement (iv) recommended calibrating procedures and equipment (b) Type and purpose of calibration (c) Methods of calibrating to recognized standards (d) Type, care and use of calibrating equipment: <ul style="list-style-type: none"> (i) standard gases and cylinders (ii) Orsats (e) Methods of checking and adjusting display device zero (f) Methods of connecting and applying calibrating equipment (g) Importance of feeding calibrating gas within correct flow and pressure limits (h) Methods of interpreting display device measurement (i) Importance of allowing adequate time for stabilization (j) Procedures for setting display device range adjustment (k) Importance of re-checking calibration procedure (l) Methods of measuring sample stream using Orsat for purposes of verifying calibration (m) Procedures for determining oxygen content in air using Orsat (n) Techniques and provisions of applying air in lieu of standard gas, where application and range permit (o) Science: <ul style="list-style-type: none"> (i) composition and properties of air (ii) gas laws (iii) properties, storage and use of gases (iv) chemical absorption of gases (v) systems, units and techniques of measurement

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 2: Paramagnetic

OPERATIONS

KNOWLEDGE

3. Servicing paramagnetic analysing systems

- (a) Interpretation of drawings, specifications, manufacturer's manuals and relevant handbooks to determine:
 - (i) type and operating principles
 - (ii) component construction
 - (iii) circuit detail
 - (iv) application data
 - (v) recommended routine maintenance
 - (vi) trouble shooting procedures
 - (vii) spare parts
- (b) Type of measurement methods:
 - (i) test body displacement
 - (ii) heat exchange
- (c) Type of detection and measuring systems:
 - (i) deflecting
 - (ii) null balance
 - (iii) thermal convection
- (d) Type, purpose and function of:
 - (i) sample purge and vent systems
 - (ii) detection and transmission systems
 - (iii) measurement and display devices
- (e) Type, purpose and function of system components:
 - (i) magnets and pole pieces
 - (ii) test bodies (glass and coated glass spheres) and suspension systems
 - (iii) measurement and reference filament detectors and electrodes
 - (iv) lens, mirrors, prisms, lamps and photo tubes
 - (v) heaters, thermostats, thermistors, temperature and pressure compensators
 - (vi) pumps, aspirators, valves, filters, traps and miscellaneous flow indicating and regulating devices
 - (vii) regulated power supplies and rectifiers
 - (viii) amplifiers, servo-mechanisms, potentiometers, bridges and slidewires
 - (ix) drive mechanisms, charts, scales and inking systems
 - (x) other

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 2: Paramagnetic

OPERATIONS

KNOWLEDGE

3. Servicing paramagnetic
analysing systems (cont'd)

- (f) Methods of inspecting, removing, repairing, testing and replacing system components
- (g) Techniques of identifying and localizing system malfunctions
- (h) Methods of checking and importance of maintaining, correct sample temperature, pressure and flow rates
- (i) Effects of sample line contamination and leaks, and methods of checking and correcting
- (j) Methods of cleaning and draining filters and traps
- (k) Methods of inspecting for wear, cleaning and lubricating, pivots, bearings, hinges and mechanical drives
- (l) Type, care, use, storage and hazards of cleaning agents and lubricants
- (m) Methods of cleaning, adjusting and aligning optical systems
- (n) Procedures for checking electrical connections, conductors and components for:
 - (i) security
 - (ii) resistance and capacitance
 - (iii) insulation
 - (iv) continuity
 - (v) grounding
 - (vi) output (potential, current, frequency and phase)
 - (vii) performance
- (o) Type, care and use of electrical test meters and equipment
- (p) Methods of cleaning slidewires and wipers
- (q) Materials and procedures for checking and adjusting mechanical and electrical zero
- (r) Techniques of using air for checking system where range and application permit
- (s) Methods of adjusting gain and sensitivity
- (t) Mathematics:
 - (i) graphs to determine electrical component characteristics
 - (ii) algebraic equations and formulae for calculation of electrical measurements

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 2: Paramagnetic

OPERATIONS

KNOWLEDGE

3. Servicing paramagnetic
analysing systems (cont'd)

(u) Science:

- (i) simple chemical formulae
- (ii) oxygen, properties in a magnetic field
- (iii) composition of air
- (iv) gas laws
- (v) type of lubricants and their uses
- (vi) organic solvents
- (vii) systems, units and techniques of measurement
- (viii) sources, reflection and refraction of light
- (ix) heat transfer and measurement
- (x) electricity and electronics
- (xi) drives
- (xii) Bernoullis' theorem

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 3: Infra-red and Ultraviolet
Analyzing Systems

OPERATIONS	KNOWLEDGE
<hr/>	
1. Installing analysing systems	<ul style="list-style-type: none">(a) Interpretation of drawings, specifications and manufacturer's manuals to determine:<ul style="list-style-type: none">(i) purpose and function of the analysing system(ii) components(iii) location(iv) electrical circuitry and power requirements(v) sample system piping layout(b) Importance of adherence to relevant codes(c) Type of analysing systems:<ul style="list-style-type: none">(i) laboratory spectrophotometer(ii) continuous process(iii) dispersive and non-dispersive(iv) single, double and triple beam(d) Type and purpose of components(e) Methods of mounting analysing systems:<ul style="list-style-type: none">(i) console(ii) table(iii) panel(iv) field(f) Considerations when mounting components for:<ul style="list-style-type: none">(i) accessibility(ii) orientation(g) Importance of avoiding extreme ambient conditions(h) Techniques of installing wiring harness and connecting electrical conductors(i) Importance of colour coding and identification of electrical conductors(j) Methods, purpose and effects of conductor shielding(k) Techniques of checking circuitry for correct installation(l) Type, care and use of electrical test meters(m) Type, purpose and function of sample and purge system components(n) Methods of installing sample, purge and vent systems

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 3: Infra-red and Ultraviolet
Analysing Systems

OPERATIONS

KNOWLEDGE

- | | |
|---|---|
| 1. Installing analysing systems
(cont'd) | (o) Methods of installing and connecting
tube and pipe
(p) Techniques and materials used in
cleaning tube and pipe
(q) Methods and importance of leak checking
sample, purge and vent systems
(r) Type, care and use of tools
(s) Procedures for checking completed
analyser installation
(t) Mathematics -
linear measurement for layout
(u) Science:
(i) basic electricity
(ii) electrical circuitry
(iii) elementary electronics
(iv) elementary scientific measure-
ments
(v) Pascal's principle and
Bernoullis' theorem
(vi) optical instruments
(vii) nature of light
(viii) absorption, infrared and
ultraviolet
(ix) humidity and its measurement
(x) heat transfer
(xi) atmospheric corrosion |
|---|---|

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 3: Infra-red and Ultraviolet
Analysing Systems

OPERATIONS	KNOWLEDGE
<hr/>	
2. Calibrating analysing systems	<ul style="list-style-type: none">(a) Interpretation of manufacturer's manuals to determine:<ul style="list-style-type: none">(i) principle of operation(ii) calibration and alignment procedures(iii) recommended calibrating equipment(iv) range and units of measurement(b) Type and purpose of calibration(c) Methods of calibrating to recognized standards:<ul style="list-style-type: none">(i) electrical and mechanical components(ii) optical systems(d) Techniques of balancing and focussing source beams(e) Procedures for synchronizing and phasing source beam interrupters, cams and breakers(f) Methods of tuning and aligning oscillators and amplifiers(g) Procedures for setting and synchronizing controls, drive mechanisms and micrometer scales(h) Techniques of achieving and recognizing optimum optical alignment and focus(i) Importance of following the correct sequence in alignment procedure(j) Procedures for calibrating measuring devices(k) Methods of adjusting for zero, range and linearity(l) Type, care and use of electrical test equipment:<ul style="list-style-type: none">(i) portable potentiometers(ii) decade boxes R, C and L(iii) portable bridges R, C and L(iv) oscilloscope(m) Type, care and use of standard calibrating gases(n) Type, care and use of tools

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 3: Infra-red and Ultraviolet
Analyzing Systems

OPERATIONS

KNOWLEDGE

2. Calibrating analysing
systems (cont'd)

(o) Mathematics:

- (i) percentage to establish calibrating points
- (ii) ratio and proportion to determine calibration adjustments
- (iii) powers and roots to calculate electrical test equipment settings
- (iv) algebraic equations for electrical measurement calculations
- (v) logs for interpretation of measurement units (transmittance and absorbance)
- (vi) geometry for calculation of optical alignment adjustments

(p) Science:

- (i) nature of light
- (ii) sources of light
- (iii) transmission of light
- (iv) reflection of light
- (v) refraction of light
- (vi) electromagnetic spectrum
- (vii) absorption (infra-red and ultraviolet)
- (viii) dispersion
- (ix) gas laws
- (x) scientific measurement
- (xi) elementary electronics

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 3: Infra-red and Ultraviolet
Analysing Systems

OPERATIONS	KNOWLEDGE
3. Servicing analysing systems	<ul style="list-style-type: none"> (a) Interpretation of manufacturer's manuals and other relevant handbooks to determine: <ul style="list-style-type: none"> (i) suggested repair and servicing techniques (ii) recommended routine maintenance procedures (iii) spare parts available (b) Interpretation of circuit drawings and schematics to determine: <ul style="list-style-type: none"> (i) significant electrical check points (ii) circuit values (c) Type, purpose and function of electrical circuits and components: <ul style="list-style-type: none"> (i) sources and detectors (ii) power supplies and rectifiers (iii) amplifiers and oscillators (iv) bridges and potentiometers (v) servo mechanisms and motors (vi) miscellaneous circuit components (RC and L) (vii) other (d) Techniques of identifying and isolating electrical malfunctions (e) Methods of adjusting, repairing and replacing circuit components (f) Importance of system realignment after component replacement (g) Methods of measuring and adjusting miscellaneous electrical values in the circuit (h) Type, care and use of electrical test equipment (i) Procedures for cleaning and adjusting slidewires and contacts (j) Type, care and use of organic cleaning solvents (k) Type, purpose and function of mechanical components: <ul style="list-style-type: none"> (i) pulley and gear drives (ii) pivots and bearings (iii) clutches and cams (l) Importance of frequent inspection for wear and proper operation

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 3: Infra-red and Ultraviolet
Analysing Systems

OPERATIONS

KNOWLEDGE

3. Servicing analysing
systems (cont'd)

- (m) Methods of repairing, replacing and adjusting mechanical devices
- (n) Type, function and use of lubricants
- (o) Type, purpose and function of optical components:
 - (i) monochromators
 - (ii) cells
 - (iii) mirrors and windows
 - (iv) collimeters
 - (v) prisms
 - (vi) gratings and adjustable slits
- (p) Methods of inspecting, replacing and adjusting optical components
- (q) Importance of system re-alignment after component replacement
- (r) Techniques in handling optical parts
- (s) Importance of wearing rubber gloves
- (t) Results of moisture on rocksalt prisms
- (u) Procedures for determining need for cleaning, buffing and re-grinding of optical parts
- (v) Type, care and use of organic solvents
- (w) Results of using incorrect cleaning solvents
- (x) Type, care and use of rouges and cloths
- (y) Importance of avoiding scratches to aluminized or precious metallised surfaces
- (z) Type, care and use of drying agents
- (aa) Type, purpose and function of sample and purge system components:
 - (i) flow and pressure regulators and indicators
 - (ii) temperature control devices and indicators
 - (iii) miscellaneous valves and fittings, tubing and pipe
- (bb) Methods of adjusting, repairing and replacing sample and purge system components
- (cc) Techniques of tracing and repairing system leaks
- (dd) Type, care and use of servicing tools and equipment

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 3: Infra-red and Ultraviolet
Analyzing Systems

OPERATIONS	KNOWLEDGE
3. Servicing analysing systems (cont'd)	(ee) Mathematics: <ul style="list-style-type: none">(i) linear measurement for replacement and adjustment(ii) ratio and proportion for adjustments(iii) geometry for optical parts replacement (ff) Science: <ul style="list-style-type: none">(i) elementary electricity(ii) dry cells and storage batteries(iii) electric motors(iv) rectification(v) elementary electronics(vi) measurement of power and energy(vii) friction(viii) fits and clearances(ix) gear drives(x) ratchets and cams(xi) metals for bearings(xii) type of lubricants and their use(xiii) organic solvents(xiv) optical instruments

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 4: Mass Spectrometers

OPERATIONS

KNOWLEDGE

1. Installing mass spectrometers
 - (a) Interpretation of drawings, specifications, and manufacturer's literature to determine:
 - (i) components
 - (ii) location
 - (iii) assembly procedures
 - (iv) tubing layout, connections, and service requirements
 - (v) electrical circuit layout, connections, and power requirements
 - (vi) pre-start up checks and procedures
 - (b) Importance of adherence to relevant codes and regulations
 - (c) Type and purpose of major components:
 - (i) sample and high vacuum systems
 - (ii) ion source analysing and collecting systems
 - (iii) measuring, amplifying, and display systems
 - (iv) power supplies and controls
 - (d) Procedures and care in unpacking components and accessories
 - (e) Methods of removing shipping blocks and fasteners
 - (f) Methods of assembling components
 - (g) Procedures for locating and mounting components
 - (h) Considerations when mounting components for:
 - (i) accessibility
 - (ii) orientation
 - (i) Methods of installing gaskets and seals
 - (j) Importance of maintaining cleanliness of components and parts during assembly and mounting operations
 - (k) Importance of extreme care in general handling of delicate components
 - (l) Effects of oil, moisture, dirt, and finger prints on high voltage insulators and components under high vacuum
 - (m) Importance of removing clinging ferrous materials from magnet pole pieces
 - (n) Effects of strong magnetic fields on tools, meters, and wristwatches, etc.

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 4: Mass Spectrometers

OPERATIONS	KNOWLEDGE
<hr/>	
1. Installing mass spectrometers (cont'd)	<ul style="list-style-type: none">(o) Techniques of achieving and checking parallelism, fits and clearances(p) Methods of installing, connecting and leak testing glass, metal, and plastic tubing and hose(q) Procedures for identifying, testing, and connecting electrical conductors and harnesses(r) Importance of pre-start up checks such as:<ul style="list-style-type: none">(i) checking pump oil levels(ii) setting belt tensions(iii) positioning controls(iv) other(s) Procedures for evacuating and checking high vacuum systems(t) Methods of activating and checking ion source analysers, power supplies, and amplifiers(u) Techniques of interpreting miscellaneous indicators, setting and adjusting controls(v) Type, care, use and storage of tools and equipment(w) Mathematics -<ul style="list-style-type: none">linear measurement for layout(x) Science:<ul style="list-style-type: none">(i) fits and clearances(ii) mechanical drives(iii) Bernoullis' theorem(iv) flow through pipes(v) type of lubricants and their uses(vi) magnetism(vii) conductors and insulators(viii) elementary circuitry(ix) ammeters, ohmmeters and voltmeters

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 4: Mass Spectrometers

OPERATIONS

KNOWLEDGE

2. Calibrating mass spectrometers
- (a) Interpretation of manufacturer's literature, relevant handbooks and local procedures to determine:
 - (i) calibration techniques procedures and recommendations
 - (ii) frequency of calibration
 - (iii) operating theory
 - (b) Type and purpose of calibration
 - (c) Methods of calibrating
 - (d) Methods and importance of checking background spectrum prior to calibration
 - (e) Type and purpose of pure gases in calibration procedure
 - (f) Techniques of introducing calibrating gases
 - (g) Type, care, use and hazard of gas cylinders and sample bombs
 - (h) Procedures for setting miscellaneous controls, switches and potentiometers
 - (i) Techniques of interpreting and adjusting for optimum peak shape on recorder
 - (j) Significance and methods of determining pattern and sensitivity of compounds
 - (k) Methods of computing sample analysis
 - (l) Importance of considering background and impurity spectrums in sample computations
 - (m) Purpose and function of reference calibration tables
 - (n) Mathematics:
 - (i) ratio and proportion of calculate sensitivity
 - (ii) percentage to calculate patterns
 - (iii) graphs and tables to interpret compound patterns
 - (iv) algebraic equations and formulae to understand basic operating theory and calculate analysis

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 4: Mass Spectrometers

OPERATIONS	KNOWLEDGE
<hr/>	
2. Calibrating mass spectrometers (cont'd)	(o) Science: <ul style="list-style-type: none">(i) atomic theory(ii) percentage composition from formula(iii) chemical formula and equations(iv) elements and compounds(v) composition and properties of air(vi) gas laws(vii) molecular weights of gases(viii) ionization of gases(ix) preparation, properties, storage and use of gases(x) systems, units and techniques of measurement(xi) Pascal's principle(xii) mass and energy(xiii) electricity(xiv) electronics

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 4: Mass Spectrometers

OPERATIONS

KNOWLEDGE

3. Servicing mass spectrometers
- (a) Interpretation of drawings, manufacturer's literature, and relevant handbooks to determine:
 - (i) type and purpose
 - (ii) operating principles
 - (iii) component types, materials, construction and arrangement
 - (iv) electrical circuit functions and data
 - (v) recommended routine maintenance, servicing, and trouble shooting procedures
 - (vi) spare parts
 - (b) Functions of mass spectrometers
 - (c) Type and purpose of sample and high vacuum system components:
 - (i) vacuum pumps and pump motors
 - (ii) flasks
 - (iii) expansion chambers
 - (iv) stop cocks, valves, tubing and manifolds
 - (v) manometers
 - (vi) heaters and coolers
 - (vii) molecular flow leak device and capillaries
 - (viii) traps, dryers and filters
 - (ix) flow, pressure, and temperature indicators and regulators
 - (x) manometers and microtmanometer type vacuum gauges
 - (d) Type and purpose of ion source analyser and collector components:
 - (i) ion injectors (cycloid tubes)
 - (ii) magnets and magnetic shunts
 - (iii) pre-amplifiers
 - (iv) ionization and thermocouple type vacuum gauges

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 4: Mass Spectrometers

OPERATIONS	KNOWLEDGE
3. Servicing mass spectrometers (cont'd)	<ul style="list-style-type: none">(e) Type and purpose of measuring, amplifying, power supply and control system circuits and components<ul style="list-style-type: none">(i) oscillators(ii) phase detectors and demodulators(iii) transformers, chokes, filters and saturable reactors(iv) relays, solenoids, and miscellaneous switches(v) voltage and current regulators, rectifiers and diodes(vi) timers and thermal switches(vii) electron and electrometer tubes and electron multipliers(viii) miscellaneous resistors and capacitors(ix) lamps and heaters(x) indicating ammeters(xi) recording potentiometers(f) Servicing methods and considerations(g) Advantages of maintaining a servicing log-book for recording pertinent servicing data(h) Techniques for determination and isolation of system malfunctions(i) Interpretation of ammeters, voltmeters and recorders(j) Methods of removing, testing, repairing, and replacing components(k) Techniques of detecting and repairing leaks in sample and high vacuum systems(l) Type and method of replacing packing, seals and gaskets(m) Methods of eliminating, and techniques in recognizing, symptoms of contamination in sample and vacuum systems(n) Methods of cleaning and replenishing filters and driers(o) Methods of cleaning and drying components under high vacuum(p) Importance of scrupulous cleanliness of sample and high vacuum system components(q) Type, care, use, and hazard of organic solvents and acids

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 4: Mass Spectrometers

OPERATIONS

KNOWLEDGE

3. Servicing mass spectrometers
(cont'd)

- (r) Procedures for checking, adding and replacing pump lubricants
- (s) Type, care, use and storage of lubricants
- (t) Methods of visually inspecting component parts, tubing and hoses for cracks, wear and security
- (u) Techniques of dismantling and assembling components
- (v) Procedures for fitting, aligning, and gapping component parts
- (w) Methods of checking circuits and circuit components for:
 - (i) voltage
 - (ii) current
 - (iii) frequency
 - (iv) phase
 - (v) resistance
 - (vi) insulation
 - (vii) continuity
 - (viii) capacity
 - (ix) performance
- (x) Importance of extreme care and involved hazards when working with high voltage
- (y) Type, care and use of electrical test meters:
 - (i) V.O.M.'s
 - (ii) V.T.V.M.'s
 - (iii) oscilloscope
 - (iv) meggers
 - (v) tube testers
 - (vi) impedance bridges
 - (vii) frequency meters
 - (viii) signal generators
- (z) Effects of, and methods of detecting and correcting loose connections, electrical noise, inadequate shielding and grounding
- (aa) Methods of removing dust and dirt from electronic components
- (bb) Methods of cleaning contacts and slide-wires
- (cc) Type, care, use and storage of tools

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 4: Mass Spectrometers

OPERATIONS	KNOWLEDGE
<hr/>	
3. Servicing mass spectrometers (cont'd)	(dd) Mathematics: <ul style="list-style-type: none">(i) linear measurement for setting clearances(ii) graphs, algebraic equations, and formulae for calculating electrical measurement and establishing component performances (ee) Science: <ul style="list-style-type: none">(i) air pressure and its measurement(ii) gas laws(iii) type of lubricants and their uses(iv) organic solvents and acids(v) systems, units and techniques of measurement(vi) Pascal's principle(vii) heat transfer(viii) temperature indicators and scales(ix) electricity(x) electronics(xi) fits and clearances(xii) pressure due to head and flow through pipes(xiii) Bernoullis' theorem(xiv) magnetism(xv) ionization of gases(xvi) molecular structure

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 5: Gas Chromatography

OPERATIONS

KNOWLEDGE

1. Installing gas chromatograph systems

- (a) Interpretation of drawings, specifications and manufacturer's literature to determine:
 - (i) type, purpose and function
 - (ii) components
 - (iii) location
 - (iv) air, water, steam, carrier gas, sample and vent system requirements and tube layout
 - (v) electrical circuitry, connections and power requirements
 - (vi) preliminary checking procedures
- (b) Importance of adherence to relevant codes and regulations
- (c) Classification of systems:
 - (i) laboratory type
 - (ii) continuous process type
- (d) Type and purpose of system components
- (e) Methods of mounting components
- (f) Considerations when mounting components for:
 - (i) accessibility
 - (ii) orientation
 - (iii) security
 - (iv) avoidance of extreme corrosive and temperature environments
- (g) Methods of installing and connecting tube and pipe
- (h) Tube and pipe installation considerations:
 - (i) extreme cleanliness of carrier gas and sample lines
 - (ii) effects of line length on fluid transportation
 - (iii) purpose and importance of line slope where requested on drawings
 - (iv) effects of leaking lines
- (i) Techniques and materials used for cleaning and leak checking tube and pipe
- (j) Methods of identifying, connecting and testing electrical conductors
- (k) Importance of checking detector signal conductors for:
 - (i) shielding
 - (ii) correct grounding of shielding
 - (iii) separate cable or conduit run

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 5: Gas Chromatography

OPERATIONS	KNOWLEDGE
1. Installing gas chromatograph systems (cont'd)	(1) Procedures for placing system in operation and checking correct function: <ul style="list-style-type: none">(i) positioning and adjustment of miscellaneous regulators and controls(ii) observation and interpretation of miscellaneous indicators and readout devices(iii) other (m) Type, care, use and storage of electrical test meters, tools and equipment
	(n) Mathematics - linear measurement for layout
	(o) Science: <ul style="list-style-type: none">(i) heat transfer(ii) corrosion(iii) systems, units and techniques of scientific measurement(iv) organic solvents(v) Bernoullis' theorem(vi) electrical circuitry(vii) voltmeter, ammeter and ohmmeter(viii) conductors and insulators

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 5: Gas Chromatography

OPERATIONS

KNOWLEDGE

2. Calibrating gas chromatograph systems

- (a) Interpretation of manufacturer's literature and relevant handbooks to determine:
 - (i) recommended calibrating procedures
 - (ii) application and calibration data
- (b) Method and purpose of calibration
- (c) Techniques of calibrating using standard samples
- (d) Methods of introducing standard samples
- (e) Care, use and hazards of gas cylinders and sample bombs
- (f) Considerations when employing standard samples as basic of system calibration:
 - (i) methods of preparing standard samples
 - (ii) methods of confirming standard sample composition
 - (iii) techniques of maintaining continuity in composition of standard sample supplies
 - (iv) importance of avoiding contamination of standard samples and containers
 - (v) effects of stratification of standard sample components and procedures for eliminating
 - (vi) importance of introducing standard samples and carrier gases under proper and controlled conditions of pressure, flow and temperature
 - (vii) significance of allowing adequate flushing of columns and sampling system with standard samples before calibrating
- (g) Methods of zeroing data readout devices
- (h) Procedures for adjusting timers and programming functions
- (i) Techniques of identifying component peaks in the data readout spectrum trace
- (j) Effects of detector circuit current and methods of adjusting range attenuators
- (k) Importance of recording component peak heights

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 5: Gas Chromatography

OPERATIONS	KNOWLEDGE
<hr/>	
2. Calibraing gas chromatograph systems (cont'd)	<ul style="list-style-type: none">(l) Importance of repeating sample spectra to ensure reproducibility(m) Techniques of chromatogram interpretation(n) Methods and considerations in establishing quantitative analysis using peak area and peak height(o) Purpose and use of planimeters(p) Methods of checking and adjusting using baragraph presentation of data(q) Importance of recording all adjustments and settings(r) Mathematics:<ul style="list-style-type: none">(i) percentage to establish data readout(ii) triangular mensuration and Simpson's rule to calculate peak area(iii) circular measure, powers and roots for interpretation of planimeters(iv) interpretation of graphs in applying corrective considerations in calculating peak area(v) cylindrical volume calculations to prepare and establish standard samples(s) Science:<ul style="list-style-type: none">(i) Avogadro's principle(ii) law of comgining gas volumes(iii) gas laws(iv) preparation and properties of gases(v) scientific measurement(vi) separation and resolution of mixtures(vii) heat transfer and measurement(viii) Bernoullis' theorem(ix) electricity(x) electronics

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 5: Gas Chromatography

OPERATIONS

KNOWLEDGE

3. Servicing gas chromatograph systems

- (a) Interpretation of drawings, manufacturer's manuals and relevant handbooks to determine:
 - (i) type, purpose and operating principles
 - (ii) components, their construction and location
 - (iii) column arrangements
 - (iv) electrical circuit values and checkpoints
 - (v) tubing runs and connections
 - (vi) application data
 - (vii) suggested routine inspection, maintenance and trouble shooting procedures
 - (viii) recommended spare parts
- (b) Type and purpose of major mechanisms:
 - (i) analyser (consisting of sample, carrier gas and temperature control systems, separation and detection devices)
 - (ii) control unit (consisting of operating and programming controls)
 - (iii) data presentation unit (consisting of measurement and readout devices)

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 5: Gas Chromatography

OPERATIONS	KNOWLEDGE
3. Servicing gas chromatograph systems (cont'd)	<p>(c) Type, purpose and function of sample, carrier gas and temperature control components:</p> <ul style="list-style-type: none"> (i) flow and pressure regulators and indicators (ii) needle and solenoid valves, restrictors, flow splitters and orifices (iii) miscellaneous liquid, vapour and gas, slide and rotary selection valves (iv) sample trapping systems and loop assemblies (v) injection syringes and motor driven pumps (vi) gas cylinders and sample bombs (vii) filters and traps (viii) electronic and pneumatic proportional temperature controllers, temperature regulators, thermostats, indicators, thermocouples and filled systems (ix) heating elements, exchangers and vaporizers (electric and other) (x) fans, blowers and mixing venturists (xi) insulated compartments and cabinets <p>(d) Type, purpose and function of separation and detection components:</p> <ul style="list-style-type: none"> (i) miscellaneous adsorption and partition chromatographic columns (ii) miscellaneous detector cells and filaments <p>(e) Type, purpose and function of operating and programming control components:</p> <ul style="list-style-type: none"> (i) motor driven timers and program controllers (ii) relays and solenoids (iii) diodes and diode matrices (iv) miscellaneous switches (v) miscellaneous fixed and adjustable resistors, motor driven potentiometers and range attenuators (vi) time delay devices and R.C. network (vii) miscellaneous automatic zeroing, attenuation and selection devices and networks (viii) regulated power supplies

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 5: Gas Chromatography

OPERATIONS

KNOWLEDGE

3. Servicing gas chromatograph systems (cont'd)
- (f) Type, purpose and function of measurement and readout devices:
 - (i) null balance detectors
 - (ii) self-balancing potentiometers and bridges
 - (iii) milliammeters and millivoltmeters
 - (iv) indicating lamps and tubes
 - (v) audible and visual alarms
 - (g) Type, purpose and function of measurement and readout device components:
 - (i) amplifiers
 - (ii) oscillators
 - (iii) power supplies and dry cells
 - (iv) drive motors and servomechanisms
 - (v) slidewires
 - (vi) mechanical drive mechanisms
 - (vii) integrators
 - (viii) chart inking assemblies
 - (h) Methods of testing, adjusting, removing, repairing and replacing system devices and components
 - (i) Techniques of identifying system malfunctions
 - (j) Procedures for isolating source of malfunction
 - (k) Methods and importance of frequent checking and adjustment of:
 - (i) carrier and sample gas flows and pressures
 - (ii) separation and detection compartment temperatures
 - (l) Effects of, and methods of locating and repairing leaks in the sample and carrier gas systems
 - (m) Methods of replacing, lubricating and setting tension of O-rings and seals
 - (n) Type, care, use and hazard of carrier gases and gas cylinders
 - (o) Methods of inspecting for wear, cleaning and lubricating:
 - (i) pivots and bearings
 - (ii) motors, pumps and fans
 - (iii) mechanical drives
 - (iv) slide and rotary valves
 - (v) slidewires, stepping switches and relays

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 5: Gas Chromatography

OPERATIONS	KNOWLEDGE
3. Servicing gas chromatograph systems (cont'd)	<ul style="list-style-type: none">(p) Type, care, use, storage and hazards of organic solvents and lubricants(q) Procedures for checking, cleaning and repacking chromatographic columns:<ul style="list-style-type: none">(i) symptoms of column inefficiencies(ii) methods of removing packing(iii) techniques of cleaning and drying(iv) type of cleaning agents(v) type and purpose of supports and substrates(vi) methods of preparing filling(vii) quantity of filling and methods of establishing(viii) methods of packing(ix) procedures for flushing and pre-conditioning(x) techniques of checking resolution and elution characteristics(xi) importance of adequate stabilization period(r) Techniques of checking and replacing detector filaments:<ul style="list-style-type: none">(i) symptoms of detector failure(ii) effects of poisoning of catalytic combustion filaments and methods of reactivating(iii) importance of replacing filaments in matched pairs(iv) methods and materials for high temperature soldering(v) methods of adjusting filament current(s) Methods of checking electrical components for:<ul style="list-style-type: none">(i) insulation(ii) continuity(iii) shorts(iv) grounding(v) resistance(vi) capacitance(vii) performance(t) Effects of noise and transients, and methods of detecting

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 5: Gas Chromatography

OPERATIONS

KNOWLEDGE

- | | |
|---|---|
| 3. Servicing gas chromatograph systems (cont'd) | <ul style="list-style-type: none">(u) Methods of measuring circuit and component values of:<ul style="list-style-type: none">(i) potential(ii) current(iii) frequency(iv) phase(v) Type, care, use and storage of electrical test meters:<ul style="list-style-type: none">(i) voltohmmeters(ii) vacuum tube voltmeters(iii) meggers(iv) tube testers(v) oscilloscopes(vi) capacitance bridges(w) Methods of establishing, checking and setting timers and programming mechanisms(x) Techniques of identifying and interpreting recorded bargraph and spectrum sample analysis(y) Type, care and use of tools and equipment(z) Mathematics:<ul style="list-style-type: none">(i) ratio and proportion for determining quantities of column packing materials, evaluation of data readout and setting programmers(ii) algebraic equations and formulae for calculation of electrical measurement(iii) graphs, powers and roots to determine electronic components performance characteristics |
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AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 5: Gas Chromatography

OPERATIONS	KNOWLEDGE
<hr/>	
3. Servicing gas chromatograph systems (cont'd)	(aa) Science: <ul style="list-style-type: none">(i) characteristics of solids, liquids and gases(ii) gas laws(iii) chromatography(iv) type of lubricants, viscosity ratings and uses(v) properties, storage and use of gases(vi) systems, units and techniques of measurement(vii) heat transfer and measurement(viii) electricity(ix) electronics(x) drives(xi) flow through pipes(xii) Bernoullis' theorem(xiii) venturis(xiv) fits and clearances(xv) organic solvents

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 6: Refractometry

OPERATIONS

KNOWLEDGE

1. Installing refractive index measuring systems

- (a) Interpretation of drawings, specifications and manufacturer's manuals to determine:
 - (i) type
 - (ii) location and mounting
 - (iii) electrical circuit layout and power layout
 - (iv) tubing layout
- (b) Classifications of refractive index measuring systems:
 - (i) continuous process
 - (ii) laboratory
- (c) Type and purpose of system components
- (d) Methods of installing components
- (e) Importance of adherence to relevant codes and regulations
- (f) Considerations when mounting components for:
 - (i) avoidance of extremes of temperature, vibration and mechanical shock
 - (ii) orientation
 - (iii) accessibility
- (g) Type of sample introduction and disposal methods
- (h) Type of cooling and heating systems
- (i) Procedures for installing, cleaning, connecting and leak testing tubing
- (j) Techniques and materials used in cleaning and leak checking tubing
- (k) Methods of identifying and connecting electrical conductors
- (l) Procedures for testing conductors and establishing correct power supply requirements
- (m) Type, care and use of electrical test meters
- (n) Procedures for checking completed installation
- (o) Importance of removing shipping blocks
- (p) Results of dust on optical parts
- (q) Care, use and storage of tools
- (r) Mathematics -
 - linear measurement for layout

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 6: Refractometry

OPERATIONS	KNOWLEDGE
1. Installing refractive index measuring systems (cont'd)	(s) Science: (i) systems, units and techniques of measurement (ii) heat transfer, temperature indicators and scales (iii) conductors and insulators (iv) elementary circuitry (v) voltmeter, ammeter and ohmmeter (vi) flow through pipes (vii) air pressure and its measurement (viii) optical instruments

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 6: Refractometry

OPERATIONS	KNOWLEDGE
2. Servicing refractive index measuring systems	<ul style="list-style-type: none"> (a) Interpretation of circuit schematics, manufacturer's literature and relevant handbooks to determine: <ul style="list-style-type: none"> (i) purpose and function (ii) principles of operation (iii) electrical circuit data (iv) component construction (v) recommended routine servicing and trouble shooting procedures (vi) test and alignment procedures (vii) spare parts (b) Type of system components (c) Procedures for removal, replacement, test and repair of components (d) Methods of identifying and localizing component malfunctions (e) Type, purpose and function of optical systems comprising of: <ul style="list-style-type: none"> (i) source lamps, photo cells and tubes (ii) mirrors, lens, prisms and slits (iii) sample, reference and compensating prisms (iv) transparent scales, reticules and control dials (v) reference liquids and prism contacting fluids (vi) other (f) Methods of inspecting and cleaning optical parts (g) Importance of employing correct techniques and materials when cleaning optics (h) Procedures for aligning optical systems (i) Methods of utilizing test pieces and standard samples in alignment procedures (j) Type and purpose of optical adjustments and compensations, and methods of setting (k) Techniques of recognizing optimum alignment and compensation (l) Significance of matching photo-cells (m) Interpretation of read-out facilities

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 6: Refractometry

OPERATIONS	KNOWLEDGE
<hr/>	
2. Servicing refractive index measuring systems (cont'd)	<ul style="list-style-type: none">(n) Type and purpose of sample system components:<ul style="list-style-type: none">(i) flow and pressure regulators and indicators(ii) heat exchangers, temperature controllers and indicators (electrical and other)(iii) filters and traps(o) Sample conditions and methods of optimizing sample control(p) Procedures for leak testing and cleaning sample tubing and components(q) Type and purpose of measuring circuits, transmission and readout devices and components:<ul style="list-style-type: none">(i) Wheatstone bridges and potentiometers(ii) amplifiers(iii) power supplies and rectifiers(iv) balancing meters and helipot(v) miscellaneous circuit component (R.C. and L.)(r) Procedures for checking component performance(s) Methods of measuring, adjusting and correcting miscellaneous circuit faults and values(t) Procedures for calibrating and adjusting readout devices(u) Type, care and use of electrical test meters and equipment:<ul style="list-style-type: none">(i) V.O.M.'s(ii) V.T.V.M.'s(iii) oscilloscopes(iv) tube testers(v) resistance and capacitance bridges(vi) portable potentiometers(vii) resistance decades(v) Methods of cleaning slidewires and contacts(w) Use and hazards of organic solvents

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 6: Refractometry

OPERATIONS	KNOWLEDGE
2. Servicing refractive index measuring systems (cont'd)	<ul style="list-style-type: none">(x) Type and purpose of mechanical components:<ul style="list-style-type: none">(i) pivots, bearings and hinges(ii) worm and gear, pulley and cable drives(iii) clutches and cams(iv) linkages and levers(y) Methods of inspecting for wear, cleaning and lubricating mechanical components(z) Type, method and frequency of applying lubricant(aa) Type, care, use and storage of tools and equipment(bb) Mathematics:<ul style="list-style-type: none">(i) percentage, ratio and proportion to determine calibrating adjustments(ii) powers and roots, and geometry to calculate optical adjustments(iii) graphs and algebraic equations and formula for interpretation and determination of electronic component performance characteristics, and electrical measurement(cc) Science:<ul style="list-style-type: none">(i) characteristics of solids, liquids and gases(ii) type of lubricants and their uses(iii) organic solvents(iv) systems, units and techniques of measurement(v) density(vi) nature and sources of light(vii) transmission, reflection and refraction of light(viii) composition of white light(ix) optical instruments(x) heat transfer and measurement(xi) temperature indicators and scales(xii) electricity(xiii) electronics(xiv) linkages and levers(xv) ratchets and cams(xvi) gear drivers(xvii) Bernoullis' theorem

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 7: Moisture

OPERATIONS	KNOWLEDGE
1. Installing moisture, relative humidity and dew point measuring systems	<ul style="list-style-type: none">(a) Interpretation of drawings, specifications and manufacturer's literature to determine:<ul style="list-style-type: none">(i) type of system(ii) components(iii) component location and mounting(iv) tubing layout(v) electrical connections and power requirements(b) Purpose and function of measuring systems:<ul style="list-style-type: none">(i) psychrometers for measuring R.H. of gases(ii) hygrometers for measuring R.H. of gases(iii) dew point meters for measuring dew point of gases(iv) moisture monitors for measuring water in gases, solids and liquids(c) Type of psychrometers:<ul style="list-style-type: none">(i) wet and dry thermometers(ii) wet and dry bulbs (electrical and filled system)(d) Type of hygrometers:<ul style="list-style-type: none">(i) dimensional change sensing devices (mechanical)(ii) conductivity change sensing devices (electrical)(e) Type of dew point meters:<ul style="list-style-type: none">(i) dew cup(ii) fog chamber(iii) cooled mirror(iv) vapor equilibrium(f) Type of moisture monitors:<ul style="list-style-type: none">(i) capacitance(ii) conductivity(iii) absorption and electrolysis(iv) dimensional change (mechanical)(g) Type and function of system components(h) Methods of installing components(i) Importance of adherence to relevant codes and regulations(j) Considerations when mounting components for accessibility and orientation(k) Type, form and method of positioning sensing devices

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 7: Moisture

OPERATIONS	KNOWLEDGE
1. Installing moisture, relative humidity and dew point measuring systems (cont'd)	<ul style="list-style-type: none">(l) Methods of identifying, testing and connecting electrical conductors(m) Importance of establishing good grounding on grounded electrode detectors and conductor screening(n) Care and use of electrical test meters:<ul style="list-style-type: none">(i) V.O.M.(ii) megger(o) Methods of installing and connecting tubing for:<ul style="list-style-type: none">(i) sample systems(ii) vent systems(iii) water supply systems(iv) cooling systems(p) Importance of avoiding tubing with high moisture permeability (e.g. plastic) for sample systems(q) Methods of cleaning and leak testing tubing(r) Effects of "tramp" moisture in sample systems and methods of eliminating(s) Procedures for energizing and checking system for correct function(t) Methods, care and hazards when filling dew point cooling systems with refrigerant and/or volatile liquids(u) Importance of attaching porous sleeves and wicks on wet bulbs, and establishing adequate water flow control(v) Techniques of achieving and interpreting display device measurement(w) Effects of sample tubing volume on measurement response(x) Care, use and storage of tools and equipment(y) Mathematics:<ul style="list-style-type: none">(i) linear measurement for layout(ii) cylindrical volume calculation to determine sampling lag times(z) Science:<ul style="list-style-type: none">(i) heat transfer(ii) humidity and its measurement(iii) conductors and insulators(iv) elementary circuitry(v) voltmeter, ammeter and ohmmeter(vi) pressure due to head(vii) flow through pipes(viii) properties of refrigerants

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 7: Moisture

OPERATIONS	KNOWLEDGE
2. Calibrating moisture, relative humidity and dew point measuring systems	<ul style="list-style-type: none"> (a) Interpretation of manufacturer's literature and relevant handbooks to determine: <ul style="list-style-type: none"> (i) calibration procedures (ii) application and range (iii) recommended calibrating equipment (b) Type, purpose and method of calibrating moisture analyzing systems and components (c) Care, purpose and use of calibrating equipment: <ul style="list-style-type: none"> (i) resistive and capacitive bridges and decade simulators (ii) potentiometers (iii) psychrometers (iv) thermometers (v) barometers (vi) dew cups (vii) analytical balances (viii) ovens and temperature baths (d) Techniques of connecting and applying calibrating equipment (e) Importance of considering temperature and barometric compensations (f) Methods of interpreting miscellaneous nomographs, charts, graphs and tables for units of measurement conversion, calibration and compensation data: <ul style="list-style-type: none"> (i) psychrometric charts (ii) relative humidity tables (iii) moisture content versus resistance, specific resistance, specific conductance and dielectric constant (iv) other (g) Procedures for balancing, range attenuating and reading display devices (h) Importance of allowing adequate time for measurement to reach stability (i) Techniques of adjusting zero, range, linearity and sensitivity of measuring systems (j) Importance of checking system after adjustments (k) Methods of checking and setting detector cell constants

AN ANALYSIS OF THE INDUSTRY INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 7: Moisture

OPERATIONS

KNOWLEDGE

2. Calibrating moisture, relative humidity and dew point measuring systems (cont'd)
- (1) Mathematics:
 - (i) graphs for establishing calibrating data
 - (ii) logs for interpretation of graphs
 - (iii) percentages for interpretation of R.H. scales
 - (iv) ratio and proportion to establish calibrating adjustments
 - (v) algebraic equations and formulae for conversion of measurement units
 - (m) Science:
 - (i) air pressure and its measurement
 - (ii) standard temperature and pressure
 - (iii) systems, units and techniques of measurement
 - (iv) temperature indicators and scales
 - (v) heat transfer
 - (vi) humidity and its measurement
 - (vii) linkages and levers
 - (viii) electricity
 - (ix) electronics

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 7: Moisture

OPERATIONS	KNOWLEDGE
3. Servicing moisture, relative humidity and dew point measuring systems	<ul style="list-style-type: none">(a) Interpretation of electrical schematics and manufacturer's manuals to establish:<ul style="list-style-type: none">(i) operating principles(ii) electrical circuit detail(iii) application data(iv) recommended routine servicing and trouble-shooting procedures(v) spare parts(b) Type and function of measuring systems(c) Techniques of detecting and localizing system malfunctions(d) Procedures for inspecting, testing, repairing and replacing components(e) Type, material and construction of sensing device components:<ul style="list-style-type: none">(i) conductivity and capacitance electrodes(ii) electrolysis cells(iii) hair, wood and membrane elements(iv) dunmore elements(v) glass and metal thermometers, porous sheaths and wicks(vi) polished metal surfaces, cups, chambers and glass mirrors(vii) hygroscopic salts(viii) other(f) Importance for frequent inspection of sensing devices for:<ul style="list-style-type: none">(i) wear and erosion(ii) mechanical damage(iii) contamination, corrosion and deterioration(iv) correct spacing of electrodes(v) security of electrical connections, cables and conduits(vi) cleanliness(vii) efficient functioning of wet bulb wetting facilities(g) Effects of free water, oil and miscellaneous solvents on electrolysis, mechanical and salt sensing devices(h) Procedures for cleaning and re-coating electrolysis cells

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 7: Moisture

OPERATIONS

KNOWLEDGE

3. Servicing moisture, relative humidity and dew point measuring systems (cont'd)
- (i) Type, purpose, material and function of sample, vent, cooling and water supply systems and components:
 - (i) flow, pressure, temperature and level regulators and indicators
 - (ii) aspirators, hand and motor driven pumps
 - (iii) heaters, coolers, filters, dryers, traps, reservoirs and valves
 - (iv) other
 - (j) Methods of checking and adjusting tubed sample flow rates
 - (k) Procedures for servicing and cleaning filters, dryers and traps
 - (l) Techniques of drying sample systems
 - (m) Procedures for leak testing sample and cooling systems
 - (n) Type and purpose of electrical detection and measuring circuits and components:
 - (i) resistance, capacitance and inductance bridges
 - (ii) potentiometers and variable oscillators
 - (iii) voltmeters and ammeters
 - (iv) power supplies, rectifiers and dry cells
 - (v) amplifiers and servomechanisms
 - (vi) attenuator and filter circuits
 - (vii) other
 - (o) Procedures for measuring and establishing electrical circuit and component values and performance
 - (p) Care, use and storage of electrical test meters
 - (q) Techniques of simulating sensing device signals using impedance decade devices and portable potentiometers
 - (r) Methods of cleaning slidewires and miscellaneous electrical contacting devices

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 7: Moisture

OPERATIONS	KNOWLEDGE
3. Servicing moisture, relative humidity and dew point measuring systems (cont'd)	<ul style="list-style-type: none"> (s) Type, purpose and procedure for inspecting mechanical drives, links, levers, pivots, bearings and sliding surfaces for: <ul style="list-style-type: none"> (i) cleanliness (ii) friction (iii) wear (iv) corrosion (v) adequate lubrication (t) Techniques of cleaning mechanical parts and chart inking assemblies (u) Care, use and hazards of cleaning agents (v) Type and method of applying lubricants (w) Care, use and storage of tools and equipment (x) Mathematics: <ul style="list-style-type: none"> (i) linear measurement to determine electrode spacing (ii) interpretation of graphs to establish electrical component performance characteristics (iii) powers and roots to calculate decade simulator values (y) Science: <ul style="list-style-type: none"> (i) electrolysis (ii) corrosion (iii) characteristics of solids, liquids and gases (iv) simple chemical formulae and equations (v) acids, bases and salts (vi) properties and composition of air (vii) vapour pressure of liquids (viii) type of lubricants and their uses (ix) organic solvents and acids (x) hygroscopic substances (xi) heat transfer (xii) electricity (xiii) electronics (xiv) friction

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 8: Emission Spectroscopy

OPERATIONS

KNOWLEDGE

1. Installing emission analysers
- (a) Interpretation of drawings, specifications and manufacturer's literature to determine:
 - (i) components
 - (ii) location and mounting
 - (iii) electrical circuit layout, connections and power requirements
 - (iv) pipe and tube layout, connections and service requirements
 - (b) Adherence to relevant codes and regulations
 - (c) Type of emission analysers:
 - (i) spectrometers
 - (ii) spectrographs and densitometers
 - (iii) photometers
 - (iv) other
 - (d) Principle components:
 - (i) source units
 - (ii) detector units
 - (iii) optical benches
 - (iv) data reduction and readout devices
 - (v) power supplies
 - (vi) cooling water, air and exhaust systems
 - (vii) other
 - (e) Procedures for unpacking, assembling and installing components
 - (f) Importance of extreme care in handling optical benches and gratings
 - (g) Methods of locating and mounting components
 - (h) Considerations when mounting components for:
 - (i) accessibility
 - (ii) orientation
 - (i) Procedures for installing, connecting, flushing and leak testing pipe and tube
 - (j) Methods of identifying, connecting and testing electrical cables and conductors
 - (k) High voltage conductor installation techniques
 - (l) Methods and importance of grounding source units and conductor shielding

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 8: Emission Spectroscopy

OPERATIONS	KNOWLEDGE
<hr/>	
1. Installing emission analysers (cont'd)	(m) Procedures for checking installation (n) Type, care, use and storage of electrical test meters, tools and equipment (o) Mathematics - linear measurement for layout (p) Science: (i) fits and clearances (ii) flow through pipes (iii) conductors and insulators (iv) elementary circuitry (v) voltmeter and ohmmeter

BLOCK 16: Analytical Instruments UNIT 8: Emission Spectroscopy

OPERATIONS

KNOWLEDGE

2. Calibrating emission analysers
- (a) Interpretation of drawings, manufacturer's literature and local procedures to determine:
 - (i) calibration and alignment procedures
 - (ii) calibrating data
 - (iii) theory of operation
 - (b) Type, purpose and function of analyser
 - (c) Purpose of calibration and alignment
 - (d) Purpose and function of controls
 - (e) Procedures for establishing optical alignment
 - (f) Techniques of recognizing and methods of checking and adjusting optical systems and parts for:
 - (i) orientation
 - (ii) level
 - (iii) parallelism
 - (iv) image intensity
 - (v) beam symmetry
 - (vi) image centering
 - (vii) beam focus
 - (viii) other
 - (g) Techniques of identifying spectral regions
 - (h) Procedures for calibration
 - (i) Methods of preparing analyser and determining control settings prior to calibration
 - (j) Type, purpose and interpretation of counters and scales
 - (k) Methods of interpreting calibration charts and tables
 - (l) Methods of exposure
 - (m) Techniques of interpreting photographic plates and readout devices
 - (n) Techniques of adjusting for optimum calibration
 - (o) Type, care and use of standard image density plates, spectrographically standardized substances and pure metal samples

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 8: Emission Spectroscopy

OPERATIONS	KNOWLEDGE
<hr/>	
2. Calibrating emission analysers (cont'd)	(p) Mathematics: <ul style="list-style-type: none">(i) graphs, tables, linear, angular and metric measurement to determine control settings and adjustments(ii) algebraic equations and formulae to calculate calibration adjustments (q) Science: <ul style="list-style-type: none">(i) modern atomic theory(ii) nature, sources, transmission, reflection and refraction of light(iii) spectral emission and dispersion(iv) elements and compounds(v) systems and units of measurement

BLOCK 16: Analytical Instruments UNIT 8: Emission Spectroscopy

OPERATIONS

KNOWLEDGE

-
3. Servicing emission analysers
- (a) Interpretation of drawings, manufacturer's literature and relevant hand-books to determine:
 - (i) operating principles
 - (ii) component types, materials, construction and arrangement
 - (iii) electrical circuit functions and detail
 - (iv) recommended routine servicing and trouble-shooting procedures
 - (v) spare parts
 - (b) Type, purpose and function of emission analysers
 - (c) Purpose and function of source units, power supplies and components:
 - (i) voltage regulators
 - (ii) tubes, transformers and rectifiers
 - (iii) capacitors, inductances and resistors
 - (iv) circuit interrupters and air quenches
 - (v) electrodes, ignitors and atomizers
 - (vi) analytical and auxiliary gaps
 - (vii) motors, pumps, fans and coolers
 - (viii) relays and timers
 - (ix) ammeters, voltmeters and oscilloscopes
 - (x) switches, breakers and circuit interlocks
 - (xi) other
 - (d) Methods of sample excitation:
 - (i) A.C. and D.C. arcs and sparks
 - (ii) gas flames
 - (iii) other
 - (e) Type, purpose and function of detectors:
 - (i) photographic films and plates
 - (ii) photocells and photomultipliers
 - (iii) others

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 8: Emission Spectroscopy

OPERATIONS	KNOWLEDGE
3. Servicing emission analysers (cont'd)	<ul style="list-style-type: none">(f) Type, purpose and function of optical systems and components:<ul style="list-style-type: none">(i) prisms, gratings and echelles(ii) mirrors and screens(iii) slits and lens(iv) shutters(v) other(g) Type, purpose and function of data reduction and display devices and components:<ul style="list-style-type: none">(i) densitometers and comparitors(ii) light sources and detectors(iii) optical systems(iv) beam choppers(v) amplifiers(vi) servo-mechanisms and motors(vii) potentiometers and bridges(viii) counters(ix) viewers, calculators and film processing equipment(x) other(h) Techniques in recognition and location of system malfunctions(i) Procedures for removing, repairing and replacing components and parts(j) Methods of measuring and adjusting circuit parameters(k) Methods of testing component performance(l) Type, care and use of electrical test meters and equipment(m) Methods of cleaning slidewires and contacts(n) Techniques of removing dirt and dust from optical components(o) Methods of checking mechanical components for wear and friction:<ul style="list-style-type: none">(i) cable, chain, worm and gear drives(ii) clutches, linkages and levers(iii) pivots and bearings(iv) ratchets and cams(p) Type, care and use of lubricants(q) Procedures for cleaning and replacing filters

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 8: Emission Spectroscopy

OPERATIONS	KNOWLEDGE
<hr/>	
3. Servicing emission analysers (cont'd)	(r) Type, care, use and storage of tools and equipment (s) Mathematics - graphs, algebraic equations and formulae to determine component performance characteristics (t) Science: (i) air pressure and its measurement (ii) type of lubricants and their uses (iii) organic solvents (iv) systems, units and techniques of measurement (v) optical instruments (vi) electricity (vii) electronics (viii) mechanical drives (ix) friction (x) linkages, levers, ratchets and cams

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 9: X-Ray

OPERATIONS	KNOWLEDGE
1. Installing X-Ray analysers	<ul style="list-style-type: none"> (a) Interpretation of drawings, specifications and manufacturer's literature to determine: <ul style="list-style-type: none"> (i) type and purpose (ii) components (iii) location and mounting (iv) pipe and tubing layout, connections and service requirements (v) electrical circuit layout, connections and power supply requirements (b) Adherence to relevant codes and regulations (c) Principle components of X-Ray analysers: <ul style="list-style-type: none"> (i) sources (ii) detectors (iii) monochromators and goniometers (iv) electronic counting and amplifying circuits (v) data reduction and readout circuits and devices (vi) high voltage and regulated power supplies and controls (vii) other (d) Procedures for unpacking components and removing shipping blocks (e) Methods of assembling and installing components (f) Considerations when installing components for: <ul style="list-style-type: none"> (i) accessibility (ii) orientation (g) Importance of extreme care and cleanliness when handling X-Ray sources (h) Effects of fingerprints on source windows and glass bodies (i) Methods of cleaning sources and source housings (j) Techniques of fitting, aligning and securing components and parts (k) Type and use of gaskets and seals (l) Procedures for checking and filling transformer tanks with oil (m) Type and purpose of oil (n) Methods of cleaning, installing, connecting and leak checking tubing and pipe

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 9: X-Ray

OPERATIONS

KNOWLEDGE

1. Installing X-Ray analysers
(cont'd)

- (o) Procedures for identifying, installing, connecting and testing electrical conductors and harnesses
- (p) Importance of establishing proper grounding facilities
- (q) Pre-start up considerations
- (r) Procedures for setting and adjusting operating voltages
- (s) Methods of establishing adequate cooling water flows and pressures
- (t) Type, care, and use of electrical test meters
- (u) Type, care, use and storage of tools and equipment
- (v) Mathematics -
 - linear measurement for layout
- (w) Science:
 - (i) fits and clearances
 - (ii) pressure due to head
 - (iii) flow through pipes
 - (iv) heat transfer
 - (v) conductors and insulators
 - (vi) ammeters, voltmeters and ohmmeters
 - (vii) elementary circuitry

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 9: X-Ray

OPERATIONS	KNOWLEDGE
2. Calibrating X-Ray analysing systems	<ul style="list-style-type: none">(a) Interpretation of manufacturer's literature, relevant handbooks and local procedures to determine:<ul style="list-style-type: none">(i) calibration and alignment procedures(ii) application and range(iii) recommended calibrating equipment, techniques and frequency(iv) theory of operation(b) Type and purpose of calibration(c) Calibration considerations(d) Biological effects of X-Rays(e) Type and purpose of adequate X-Ray shielding devices(f) Hazards of high voltage(g) Importance in allowing adequate warm up period of power supplies and electronic circuits before commencing calibration(h) Importance of checking and adjusting power supplies and operating voltages(i) Methods of determining and adjusting geiger tube threshold voltages(j) Type, care, use and biological effects of gamma rays when radium used to accomplish (i)(k) Importance of allowing adequate stabilization time after all electronic adjustments before judging effectiveness of adjustment(l) Procedures for calibrating rate meters and counting circuits(m) Importance of correct positioning and selection of controls, such as:<ul style="list-style-type: none">(i) input signal(ii) counting mode(iii) scanning rate(iv) time constant(v) other(n) Methods of utilizing power supply line frequency as standard input signal(o) Methods of zeroing data readout devices(p) Methods of adjusting for correct counting rate(q) Effects of scale factors and multipliers on data readout

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 9: X-Ray

OPERATIONS

KNOWLEDGE

2. Calibrating X-Ray analysing systems (cont'd)

- (r) Procedures for aligning beam path systems and devices
- (s) Type, care and use of equipment used as aids in alignment:
 - (i) alignment bars and straight edges
 - (ii) zero setting and alignment gauges
 - (iii) metal foils, filters and slits
 - (iv) fluorescent screens
 - (v) other
- (t) Methods of checking and adjusting systems for:
 - (i) level
 - (ii) clearance
 - (iii) parallelism
 - (iv) angle
 - (v) position and distance
- (u) Importance of adequately securing and locking adjustments
- (v) Methods of determining accuracy of alignment
- (w) Type, preparation, and use of standard specimens
- (x) Methods of positioning and applying standard specimens
- (y) Type and use of scatter shields and crystals
- (z) Methods of scanning
- (aa) Procedures for adjusting scan speeds and limits
- (bb) Techniques of interpreting data readout devices
- (cc) Interpretation of tables, intensity data, reference and calibration curves
- (dd) Effects of X-Ray tube anode materials and crystals on diffracted beam intensity versus angle
- (ee) Techniques of recognizing need to repeat alignment procedures
- (ff) Type, care, use and storage of tools and equipment

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 9: X-Ray

OPERATIONS	KNOWLEDGE
<hr/>	
2. Calibrating X-Ray analysing systems (cont'd)	(gg) Mathematics: <ul style="list-style-type: none">(i) linear and metric measurement to determine clearances and beam path lengths in the alignment procedure(ii) geometry and trigonometry to establish beam angles in the alignment procedure(iii) algebraic equations, ratio and proportion to calculate data read-out (hh) Science: <ul style="list-style-type: none">(i) systems, units and techniques of measurement(ii) electricity(iii) electronics(iv) X-Rays(x) radioactivity(vi) electromagnetic spectrum(vii) ionization

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 9: X-Ray

OPERATIONS

KNOWLEDGE

3. Servicing X-Ray analysers

- (a) Interpretation of drawings, manufacturer's manuals and relevant handbooks to determine:
 - (i) application
 - (ii) operating principles
 - (iii) electrical circuit functions
 - (iv) suggested routine maintenance and trouble shooting procedures
 - (v) recommended spare parts
 - (vi) biological effects of X-Rays
- (b) Type, purpose and function of X-Ray analysers
- (c) Type, purpose, material and construction of sources and detectors:
 - (i) X-Ray tubes (miscellaneous)
 - (ii) geiger-mueller tubes
 - (iii) proportional counters
 - (iv) photomultiplier tubes and crystals (scintillation counters)
 - (v) electron multiplier tubes
 - (vi) cameras and film
 - (vii) other
- (d) Focussing and beam path device types, purpose, materials, and arrangements in monochromators, goniometers and photometers:
 - (i) collimators
 - (ii) filters
 - (iii) crystal tables
 - (iv) slits
 - (v) windows
 - (vi) wedges
 - (vii) cells
 - (viii) beam choppers
 - (ix) other
- (e) Type and purpose of power supplies and controls:
 - (i) high voltage power supplies
 - (ii) D.C. power supplies
 - (iii) current stabilizers and voltage regulators
 - (iv) dry batteries

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 9: X-Ray

OPERATIONS	KNOWLEDGE
3. Servicing X-Ray analysers (cont'd)	<ul style="list-style-type: none">(f) Type, purpose and function of electronic circuits and components:<ul style="list-style-type: none">(i) amplifiers and oscillators(ii) cathode followers(iii) discriminators(iv) decade scalars, rate meters and counting circuits(v) choppers and relays(vi) timers(vii) rectifiers and diodes(viii) filters, chokes and transformers(ix) vacuum and gas tubes(x) rheostats and switches(xi) voltmeters and ammeters(xii) other(g) Type, purpose and function of self-balancing recorders, motors and drives(h) Type, purpose and function of cooling systems and components:<ul style="list-style-type: none">(i) flow and pressure indicators, regulators and interlocks(ii) filters(iii) aspirators(iv) coolers(i) Techniques of detecting and isolating system malfunctions(j) Methods of inspecting, testing, repairing and replacing components(k) Hazards of high voltage(l) Procedures for removing residual charge from high voltage circuits before servicing equipment(m) Methods of seasoning new X-Ray tubes(n) Effects of X-Ray target materials on maximum loading(o) Importance of realigning goniometers and monochromators after replacing X-Ray tubes(p) Methods of measuring and adjusting electrical circuit and component values and performance(q) Type, care, use and storage of electrical test meters and equipment

BLOCK 16: Analytical Instruments UNIT 9: X-Ray

OPERATIONS

KNOWLEDGE

3. Servicing X-Ray analysers

- (r) Methods of cleaning rheostats, slide-wires, contacts, insulators and circuit components
- (s) Procedures for cleaning cooling systems replacing filter elements and adjusting water flows and pressures
- (t) Methods of checking mechanical drives, bearings and sliding surfaces for wear and friction
- (u) Type, care and use of lubricants
- (v) Type, care and use of tools and equipment
- (w) Mathematics -
 - graphs, algebraic equations and formulae to calculate electrical measurement and establish electronic component performance
- (x) Science:
 - (i) type of lubricants and their uses
 - (ii) organic solvents
 - (iii) Pascal's principle
 - (iv) heat transfer
 - (v) mechanical drives
 - (vi) friction
 - (vii) Bernoullis' theorem
 - (viii) X-Rays
 - (ix) electricity
 - (x) electronics

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 10: Nuclear Magnetic Resonance Spectrometry

OPERATIONS	KNOWLEDGE
1. Installing N.M.R. spectrometers	(a) Interpretation of drawings, specifications and manufacturer's literature to determine: <ul style="list-style-type: none">(i) spectrometer units(ii) location(iii) electrical cable connections and power requirements(iv) tubing, pipe and hose connections and service requirements
	(b) Adherence to relevant codes and regulations
	(c) Type and purpose of spectrometer
	(d) Procedures for installing units: <ul style="list-style-type: none">(i) control consoles(ii) magnet systems(iii) other
	(e) Considerations when locating units for: <ul style="list-style-type: none">(i) accessibility(ii) adequate floor strength(iii) absence of environmental magnetic fields(iv) stable ambient temperatures(v) absence of vibration
	(f) Methods of removing shipping blocks and clamps
	(g) Methods of installing sample and reference probe assembly
	(h) Procedures for installing, connecting and leak testing filters, regulators, pipe, tubing and hose
	(i) Procedures for installing, identifying, connecting and testing electrical conductors
	(j) Purpose and function of co-axial cables
	(k) Importance of checking stability of power supply potential and frequency
	(l) Methods of compensating for transient power supply variations
	(m) Type, care and use of electrical test meters
	(n) Type, use and storage of tools and equipment
	(o) Mathematics: <ul style="list-style-type: none">linear measurement for layout

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 10: Nuclear Magnetic Resonance Spectrometry

OPERATIONS

KNOWLEDGE

1. Installing N.M.R.
spectrometers (cont'd)

(p) Science:

- (i) fits and clearances
- (ii) pressure due to head
- (iii) flow through pipes
- (iv) systems, units and techniques of measurement
- (v) temperature indicators and scales
- (vi) elementary circuitry
- (vii) conductors and insulators
- (viii) voltmeters and ohmmeters
- (ix) frequency meters
- (x) electro-magnetism

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 10: Nuclear Magnetic Resonance Spectrometry

OPERATIONS	KNOWLEDGE
2. Calibrating N.M.R. spectrometers	<ul style="list-style-type: none">(a) Interpretation of manufacturer's literature and relevant handbooks to determine:<ul style="list-style-type: none">(i) tuning and calibration procedures(ii) control functions(iii) theory of operation(b) Type and purpose of spectrometer(c) Techniques of manipulating controls to achieve adjustments of:<ul style="list-style-type: none">(i) frequencies and phase(ii) signal amplitudes(iii) noise control(iv) R.F. field strength(v) current magnitudes and direction(vi) field curvatures and shapes(vii) sweep speed, width, offset and zero(d) Purpose and method of homogeneity tuning(e) Techniques of adjusting for optimum magnetic field homogeneity and maximum signal level(f) Type, purpose and use of homogeneity tuning samples(g) Type, purpose and use of liquid calibrating standards(h) Interpretation of recorded spectrum(i) Importance of correct control selections and settings(j) Methods of determining sample spinner speed using 60 cycle fluorescent lighting(k) Purpose and method of calibrating spectrometer(l) Methods of adjusting recorder to zero reference at resonance point of calibrating standard(m) Purpose and method of performing a sweep calibration(n) Type and purpose of reference compounds(o) Procedures for adjusting recorder to reference compound resonance point

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 10: Nuclear Magnetic Resonance Spectrometry

OPERATIONS

KNOWLEDGE

2. Calibrating N.M.R.
spectrometers (cont'd)

- (p) Mathematics required to understand operating theory and functions of control adjustments:
 - (i) powers and roots
 - (ii) ratio and proportion
 - (iii) graphs
 - (iv) geometry
 - (v) trigonometry
 - (vi) algebraic equations and formulae
- (q) Science:
 - (i) chemical formulae
 - (ii) elements and compounds
 - (iii) atomic theory
 - (iv) magnetogyric ratio
 - (v) nuclear magnetic resonance
 - (vi) magnetism
 - (vii) electricity
 - (viii) electronics
 - (ix) systems, units and techniques of measurement

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 10: Nuclear Magnetic Resonance Spectrometry

OPERATIONS	KNOWLEDGE
3. Servicing N.M.R. spectrometers	<ul style="list-style-type: none">(a) Interpretation of drawings, circuit schematics, manufacturer's literature and relevant handbooks to determine:<ul style="list-style-type: none">(i) operating principles(ii) electronic circuit functions and data(iii) component specifications and ratings(iv) suggested routine maintenance and trouble shooting procedures(v) spare parts(b) Type, purpose and function of spectrometers(c) Type and purpose of electronic circuits and components:<ul style="list-style-type: none">(i) R.F. transmitters and receivers(ii) A.C. and D.C. amplifiers(iii) oscillators and modulators(iv) phase shift networks and phase detectors(v) power supplies and rectifiers(vi) current and voltage regulators(vii) integrators(viii) filters and chokes(ix) transformers and coils(x) electron tubes, transistors and crystals(xi) choppers and relays(xii) fixed and variable resistance and capacitances(xiii) miscellaneous switches and timers(xiv) voltmeters and frequency meters(xv) other(d) Type, purpose and function of magnet and probe assembly components(e) Type, purpose and function of servo-mechanisms, drive motors, chart and inking assemblies and controls(f) Type, purpose and function of water cooling systems and components:<ul style="list-style-type: none">(i) flow and temperature indicators and regulators(ii) heat exchangers and cold plates(iii) filters(iv) other

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 10: Nuclear Magnetic Resonance Spectrometry

OPERATIONS

KNOWLEDGE

3. Servicing N.M.R.
spectrometers (cont'd)

- (g) Type, purpose and function of air system components:
 - (i) pressure indicators and regulators
 - (ii) turbines
 - (iii) filters
 - (iv) driers
- (h) Techniques of recognizing and locating system malfunctions
- (i) Type and purpose of built-in test facilities
- (j) Procedures for removing, testing, repairing and replacing components
- (k) Methods of testing and adjusting circuit and component values and performance
- (l) Techniques of measuring circuit parameters:
 - (i) potential
 - (ii) frequency
 - (iii) waveform
 - (iv) resistance
 - (v) noise
 - (vi) gain
 - (vii) stability
- (m) Hazards of high voltage
- (n) Techniques and precautions when checking semi-conductors
- (o) Purpose and use of heat sinks when soldering
- (p) Type, care and use of electrical test meters and equipment:
 - (i) V.O.M.'s
 - (ii) V.T.V.M.'s and appropriate probes
 - (iii) oscilloscopes
 - (iv) tube testers
 - (v) A.F. generators
 - (vi) fluxmeters
- (q) Methods of cleaning slidewires and contacts
- (r) Methods of cleaning and replacing filter elements and traps
- (s) Procedures for checking and adjusting water flows and temperatures
- (t) Procedures for checking and adjusting air flows and pressures

. MEASUREMENT .

BLOCK 16: Analytical Instruments

UNIT 10: Nuclear Magnetic Resonance
Spectrometry

OPERATIONS	KNOWLEDGE
3. Servicing N.M.R. spectrometers (cont'd)	<ul style="list-style-type: none"> (u) Type, function and life of dessicants (v) Methods of removing water and dust from probe assembly holes and passages (w) Procedures for inspecting gear, pulley and chain drives for friction, wear and play (x) Methods of cleaning and lubricating mechanical drives and bearings (y) Type, care, use, hazard and storage of lubricants and solvents (z) Type, care, use and storage of tools and equipment (aa) Mathematics: <ul style="list-style-type: none"> (i) ratio and proportion for determining signal to noise ratio (ii) powers and roots to calculate R.M.S. potentials (iii) metric measurement to determine circuit values (iv) graphs, algebraic formulae and equations to calculate electrical measurements and electronic component performance characteristics (v) geometry and trigonometry to interpret oscilloscope patterns and waveforms (bb) Science: <ul style="list-style-type: none"> (i) Bernoullis' theorem (ii) Pascal's law (iii) heat exchange (iv) mechanical drives (v) type and use of lubricants (vi) type and use of organic solvents (vii) magnetism (viii) electricity (ix) electronics (x) molecular structure

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 11: Ionization

OPERATIONS	KNOWLEDGE
1. Installing ionization detection systems	<ul style="list-style-type: none"> (a) Interpretation of drawings, specifications and manufacturer's literature to determine: <ul style="list-style-type: none"> (i) components (ii) location and mounting (iii) tubing layout and connections (iv) electrical circuit layout, connections and power requirements (b) Importance of adherence to relevant codes and regulations (c) Type and function of ionization systems (d) Principle components: <ul style="list-style-type: none"> (i) ionization and detection assemblies (ii) sample and fuel gas systems and controls (iii) electronic measurement, amplification and control circuits (iv) data reduction and readout devices (e) Methods of assembling and installing components (f) Considerations when assembling and installing components: <ul style="list-style-type: none"> (i) orientation (ii) accessibility (iii) security (iv) cleanliness (g) Considerations in material specifications and assembly techniques for components and parts subjected to high temperature (h) Procedures for cleaning, installing, connecting and leak testing tubing (i) Importance of avoiding fuel gas leaks (e.g. hydrogen) (j) Methods of installing, identifying, connecting and testing electrical conductors and harnesses (k) Importance of observing correct polarities (l) Type, purpose and use of co-axial cables (m) Type, purpose and function of high temperature conductor insulation (n) Type, care and use of electrical test meters

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 11: Ionization

OPERATIONS	KNOWLEDGE
<hr/>	
1. Installing ionization detection systems (cont'd)	(o) Procedures and care when checking and activating systems (p) Type, care and use of tools and equip- ment (q) Mathematics - linear measurement for layout (r) Science: (i) fits and clearances (ii) flow through pipes (iii) heat transfer (iv) conductors and insulators (v) elementary circuitry (vi) ammeter, voltmeter and ohmmeter

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 11: Ionization

OPERATIONS	KNOWLEDGE
2. Calibrating ionization detection devices	<ul style="list-style-type: none">(a) Interpretation of manufacturer's literature, relevant handbooks and local procedures to determine:<ul style="list-style-type: none">(i) calibrating procedures(ii) application and range(b) Type and purpose of calibration(c) Calibration considerations(d) Procedures for calibrating data readout devices:<ul style="list-style-type: none">(i) voltmeters(ii) ammeters(iii) potentiometers(e) Type, care and use of electrical test equipment:<ul style="list-style-type: none">(i) portable potentiometers(ii) auxilliary adjustable voltage sources(iii) other(f) Procedures for calibrating ionization detection systems(g) Type, use, size and concentration of test solutions(h) Importance of allowing adequate warm-up time prior to calibration(i) Methods of adjusting fuel and carrier gases for optimum flows(j) Procedures for determining background signal(k) Methods of setting zero suppression and sensitivity controls(l) Methods of applying test solutions(m) Procedures for adjusting range attenuation and input signal impedance(n) Techniques of interpreting data readout(o) Methods of applying scale factors(p) Mathematics:<ul style="list-style-type: none">(i) percentage, ratio and proportion, and metric measurement to calculate standard solution and set gas flows(ii) powers to determine range and impedance attenuation

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 11: Ionization

OPERATIONS	KNOWLEDGE
2. Calibrating ionization detection devices (cont'd)	(q) Science: (i) elements and components (ii) atomic theory (iii) chemical formulae and equations (iv) theory of ionization (v) preparation, properties, storage and use of gases (vi) scientific measurement (vii) heat transfer (viii) pressure due to head (ix) Bernoullis' theorem (x) electricity (xi) electronics

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 11: Ionization

OPERATIONS

KNOWLEDGE

3. Servicing ionization detection system

- (a) Interpretation of drawings, manufacturer's manuals and relevant handbooks to determine:
 - (i) type, purpose and function
 - (ii) operating principles
 - (iii) application
 - (iv) component construction and materials
 - (v) electrical circuit details
 - (vi) recommended routine servicing and trouble shooting procedures
 - (vii) spare parts
- (b) Type, purpose and function of components:
 - (i) flow, pressure and temperature indicators and regulators
 - (ii) filters and traps
 - (iii) gas generators and cylinders
 - (iv) flame heads and burners, ionization gauges and tubes
 - (v) electrometers, amplifiers, demodulators and filters
 - (vi) choppers
 - (vii) attenuators
 - (viii) regulated power supplies, rectifiers, and batteries
 - (ix) indicating and recording voltmeters, ammeters and potentiometers
- (c) Procedures for inspecting, testing, repairing and replacing components
- (d) Techniques of detecting and locating system malfunctions
- (e) Methods of measuring and adjusting for optimum fuel gas, air and carrier gas flows
- (f) Effects of mal-adjusted flows on detector output signal
- (g) Procedures for and importance of frequent leak testing of tubing and connections
- (h) Care and hazards of gas cylinders
- (i) Techniques of checking burner ignition operation
- (j) Importance of recognizing gas ignition (some flames are invisible)

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 11: Ionization

OPERATIONS	KNOWLEDGE
<hr/>	
3. Servicing ionization detection system (cont'd)	(k) Procedures for dismantling and cleaning flame heads (l) Type, care, use and hazard of organic solvents and acids (m) Causes, and methods of eliminating, background noise and pick-up (n) Importance of proper circuit grounding and methods of checking (o) Procedures for measuring and establish- ing electronic circuit and component values and performance (p) Type, care and use of electrical test meters: (i) V.T.V.M.'s (ii) oscilloscopes (iii) tube testers (iv) impedance bridges (q) Methods of removing dirt and dust from electronic components (r) Methods of cleaning slidewires, contacts and terminals (s) Procedures for lubricating and checking for friction and wear (i) mechanical drives (ii) pivots and bearings (t) Type, care, use and storage of lubricants (u) Type, care, use and storage of tools and equipment (v) Mathematics - graphs, algebraic equations and formula for calculation of elec- tronic measurements and component performance

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 11: Ionization

OPERATIONS

KNOWLEDGE

3. Servicing ionization
detection system (cont'd)

(w) Science:

- (i) Bernoullis' theorem
- (ii) properties, storage and use of gases
- (iii) combustion of fuels
- (iv) air pressure and its measurement
- (v) gas laws
- (vi) ionization of gases
- (vii) type of lubricants and their uses
- (viii) organic solvents and acids
- (ix) refractory materials and ceramics
- (x) systems, units and techniques of measurement
- (xi) sources of heat
- (xii) mechanical drives
- (xiii) friction
- (xiv) electricity
- (xv) electronics

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 12: Colorimetry

OPERATIONS	KNOWLEDGE
<hr/>	
1. Installing colorimeters	<ul style="list-style-type: none">(a) Interpretation of drawings, specifications and manufacturer's instructions to determine:<ul style="list-style-type: none">(i) components(ii) location(iii) electrical layout and connections(b) Importance of adherence to relevant codes and regulations(c) Type and purpose of components(d) Methods of locating and mounting components(e) Importance in avoiding extreme condition at selected location of:<ul style="list-style-type: none">(i) temperature(ii) humidity(iii) vibration(iv) corrosive atmosphere(v) dust(vi) sunlight(f) Consideration when mounting components for accessibility(g) Methods of identifying and connecting electrical conductors and harnesses(h) Methods of determining correct potentials and polarities(i) Effects of connecting power leads across sensitive and delicate electrical indicating devices(j) Procedures for energizing and testing completed installation(k) Type, care and use of electrical test meters and tools(l) Type, and method of applying lubricant(m) Type, care, use and storage of tools and equipment

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 12: Colorimetry

OPERATIONS

KNOWLEDGE

1. Installing colorimeters
(cont'd)

(n) Science:

- (i) type of lubricants and their uses
- (ii) organic solvents
- (iii) systems, units, and techniques of measurement
- (iv) optical instruments
- (v) sources of light
- (vi) photoelectric devices
- (vii) electricity
- (viii) electronics
- (ix) atmospheric corrosion
- (x) heat transfer
- (xi) temperature measurement
- (xii) humidity and its measurement
- (xiii) elementary circuitry
- (xiv) voltage and voltmeters

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 12: Colorimetry

OPERATIONS	KNOWLEDGE
2. Calibrating colorimeters	<ul style="list-style-type: none"> (a) Interpretation of manufacturer's literature and local procedures to determine: <ul style="list-style-type: none"> (i) application (ii) recommended calibrating procedures (b) Type of colorimeters (c) Type of photometric variables and quantities colorimeter is designed for or can be adapted to measure (d) Type and purpose of calibration (e) Methods of calibrating to recognized standards (f) Type of primary, secondary and working calibrating standards: <ul style="list-style-type: none"> (i) calibrated filters (ii) calibrated lamps (iii) clean air (iv) clean solvent (v) distilled water (vi) smoked magnesium oxide (vii) miscellaneous ceramic and porcelain panels (viii) miscellaneous glass pieces and films (ix) miscellaneous fluids (x) other (g) Methods of applying calibrating standards (h) Importance of adequate warm-up period before commencing calibration (i) Procedures for correct positioning of miscellaneous controls (j) Type, purpose and method of setting optical and electrical calibrating adjustments (k) Techniques of interpreting and calculating readings from measurement and display devices and indicating scales (l) Importance of re-checking calibration after adjustment (m) Care and storage of calibrating standards (n) Mathematics - <ul style="list-style-type: none"> interpretation of curves, graphs and tables to convert colorimeter display to units of measurement

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 12: Colorimetry

OPERATIONS

KNOWLEDGE

2. Calibrating colorimeters
(cont'd)

(o) Science:

- (i) systems, units and techniques of measurement
- (ii) nature, sources and composition of light
- (iii) transmittance
- (iv) reflectance
- (v) absorbance
- (vi) electricity
- (vii) electronics

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 12: Colorimetry

OPERATIONS	KNOWLEDGE
<hr/>	
3. Servicing colorimeters	<ul style="list-style-type: none">(a) Interpretation of schematic drawings, manufacturer's literature and relevant handbooks to determine:<ul style="list-style-type: none">(i) purpose and function(ii) components and accessories(iii) operating principles(iv) electrical circuit data(v) recommended servicing procedures(vi) spare parts(b) Type and purpose of components:<ul style="list-style-type: none">(i) light sources(ii) photoelectric detectors(iii) power supplies(iv) indicating and recording electrical measurement and display devices(v) electric and electronic balancing, control, measuring and amplifying circuits and circuit components(vi) optical systems(vii) servomechanisms and motors(viii) other(c) Techniques of identifying and isolating component faults(d) Procedures for removing, repairing, testing and replacing components(e) Importance of avoiding and methods of removing dust and fingerprints on sources, detectors and optical parts(f) Importance of checking optical alignment after component replacement(g) Procedures for aligning and adjusting optical system(h) Effects on measurement due to aging and fatigue of light sources and photoelectric detectors(i) Effects of and procedures for determining excessive external light leakage(j) Procedures for measuring and establishing miscellaneous circuit and component values and performance

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 12: Colorimetry

OPERATIONS

KNOWLEDGE

3. Servicing colorimeters
(cont'd)

- (k) Type, care and use of electrical test meters
- (l) Methods and materials for cleaning rheostats, slidewires and contacts
- (m) Methods of inspecting for wear and lubricating mechanical drives, pivots and bearings
- (n) Type and method of applying lubricant
- (o) Type, care, use and storage of tools and equipment
- (p) Mathematics -
 - graphs, powers, algebraic equations and formulae for determination of electrical measurement and component performance
- (q) Science:
 - (i) type of lubricants and their uses
 - (ii) organic solvents
 - (iii) systems, units and techniques of measurement
 - (iv) optical instruments
 - (v) sources of light
 - (vi) photo electric devices
 - (vii) electricity
 - (viii) electronics

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 13: pH and Redox

OPERATIONS	KNOWLEDGE
1. Installing pH and Redox measuring systems	<ul style="list-style-type: none"> (a) Interpretation of drawings, specifications, and manufacturer's instructions to determine: <ul style="list-style-type: none"> (i) components (ii) location (iii) electrical circuit layout and connections (iv) pipe and tube layout (b) Importance of adherence to relevant codes and regulations (c) Type of measuring systems: <ul style="list-style-type: none"> (i) fixed location (ii) laboratory and portable (d) Type and purpose of components (e) Methods of installing components (f) Considerations when installing cells and sampling systems: <ul style="list-style-type: none"> (i) electrode pressure and temperature limitations (ii) electrode materials and chemical properties of measured solution (iii) adequate mixing and filtration of measured solution (iv) facilities to ensure electrode immersion under all conditions (v) arrangements to facilitate accessibility and removal of cell electrodes (vi) optimum positioning and minimum sampling capacity to reduce measuring lag (g) Methods of installing, connecting and leak testing tubing and pipe (h) Procedures for installing, identifying, testing, and connecting electrical conductors (i) Methods, purpose and importance of: <ul style="list-style-type: none"> (i) electrostatic shielding of the measuring electrode conductor (ii) proper grounding of electrode conductor shields and amplifier chassis (iii) using separate conduit run for electrode conductors (iv) ensuring high insulation value

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 13: pH and Redox

OPERATIONS

KNOWLEDGE

1. Installing pH and Redox
measuring systems (cont'd)

- (j) Effects of moisture on conductor insulation
- (k) Methods of preventing and eliminating moisture contact with electrode conductors
- (l) Type and use of dessicants
- (m) Methods of preparing electrodes for service
- (n) Procedures for energizing, testing, and placing system in operation
- (o) Type, care, use, and storage of electrical test meters, tools and equipment
- (p) Mathematics -
 linear measurement for layout
- (q) Science:
 - (i) pressure due to head
 - (ii) flow through pipes
 - (iii) temperature measurement
 - (iv) chemical properties
 - (v) pH, Eh, and rH scales
 - (vi) conductors and insulators
 - (vii) elementary circuitry
 - (viii) voltmeter, ammeter, and ohmmeter
 - (ix) drying agents

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 13: pH and Redox

OPERATIONS	KNOWLEDGE
<hr/>	
2. Calibrating pH and Redox measuring systems	<ul style="list-style-type: none">(a) Interpretation of manufacturer's literature and relevant handbooks to determine:<ul style="list-style-type: none">(i) type, range, and application(ii) recommended calibrating procedures(b) Purpose and methods of calibrating pH and redox measuring systems and components(c) Type and function of calibrating equipment:<ul style="list-style-type: none">(i) Buffer solutions(ii) thermometers(iii) resistance bridges(iv) portable potentiometers(v) auxillary adjustable voltage sources(d) Procedures for preparing buffer solutions(e) Effects of age and contamination of buffer solutions(f) Techniques of preparing electrodes for calibration procedure(g) Methods of connecting and applying calibrating equipment(h) Effects of short circuiting electrode conductors(i) Importance of correct electrode immersion depth when using buffer solutions(j) Methods of measuring solution temperature accurately(k) Interpretation of temperature/MV and temperature/resistance tables when computing manual or automatic temperature compensation(l) Methods of setting and adjusting manual temperature compensators(m) Interpretation of pH/MV tables when using auxillary voltage sources(n) Importance of allowing adequate warm up and stabilization time(o) Techniques of interpreting pH, Eh, and rH scales(p) Methods of adjusting zero, range and linearity of measuring and display device

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 13: pH and Redox

OPERATIONS

KNOWLEDGE

2. Calibrating pH and Redox
measuring systems (cont'd)

(q) Mathematics:

- (i) graphs for computing resistance/
temperatures and pH/cell potential
relationships
- (ii) algebraic equations and formulae
for calculating pH/cell potential
relationship
- (iii) percentage, weights, and measures
to determine make up of buffer
solutions

(r) Science:

- (i) simple chemical formulae
- (ii) acids, bases, salts, and neutra-
lization
- (iii) pH, rH, and Eh scales
- (iv) temperature scales
- (v) electricity
- (vi) electronics

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 13: pH and Redox

OPERATIONS	KNOWLEDGE
<hr/>	
3. Servicing pH and Redox measuring systems	<ul style="list-style-type: none">(a) Interpretation of drawings and manufacturer's literature to determine:<ul style="list-style-type: none">(i) purpose and function(ii) operating principles(iii) component construction(iv) circuit data(v) suggested routine maintenance and trouble shooting procedures(vi) recommended spare parts(b) Type of system components(c) Techniques of identifying and locating component malfunctions(d) Methods of component removal, replacement, test, and repair(e) Purpose and function of electrode assemblies:<ul style="list-style-type: none">(i) immersion type(ii) flow type(f) Classes of electrodes:<ul style="list-style-type: none">(i) reference (pH and redox)(ii) measuring (pH and redox)(iii) temperature compensators (pH only)(g) Type of electrode materials and solutions(h) Purpose of electrode "liquid junctions"(i) Causes and affects on measurement, due to loss of "liquid junction"(j) Importance of avoiding and replacing contaminated solutions(k) Methods of replenishing electrode solutions(l) Methods of cleaning and flushing electrode(m) Type, care, use and hazard of organic solvents and acids

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 13: pH and Redox

OPERATIONS

KNOWLEDGE

3. Servicing pH and Redox
measuring systems (cont'd)

- (n) Procedures for grinding and burnishing electrodes
- (o) Type, purpose and function of measuring devices and circuits:
 - (i) recording potentiometers, null balance indicators, and ammeters
 - (ii) AC and DC amplifiers
 - (iii) power supplies, rectifiers, dry and standard cells
 - (iv) relays and converters
 - (v) rheostats and slidewires
 - (vi) miscellaneous circuit components (R.C. and L.)
 - (vii) balancing motors
 - (viii) other
- (p) Methods of checking electrical component performance
- (q) Importance of using high impedance potential sources when checking amplifier with substitute cell signal
- (r) Methods of measuring, adjusting, and correcting miscellaneous circuit values:
 - (i) potential
 - (ii) current
 - (iii) impedance (R.C. and L.)
 - (iv) insulation
- (s) Methods of compensating for asymmetry potential of cells
- (t) Procedures for standardizing measuring circuit
- (u) Methods of replacing and testing dry cells and standard cells

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 13: pH and Redox

OPERATIONS	KNOWLEDGE
<hr/>	
3. Servicing pH and Redox measuring systems (cont'd)	<ul style="list-style-type: none">(v) Methods and materials for cleaning electrical components, slidewires and contacts(w) Type, care, and use of electrical test meters and equipment:<ul style="list-style-type: none">(i) V.T.V.M.(ii) tube tester(iii) portable potentiometer(iv) impedance bridges (R.C. and L.)(x) Type and purpose of mechanical components:<ul style="list-style-type: none">(i) pivots and bearings(ii) clutches and cams(iii) linkages and levers(iv) gear and pulley drives(y) Methods of inspecting for wear, cleaning and lubricating mechanical components(z) Mathematics -<ul style="list-style-type: none">powers, roots, graphs, algebraic equations and formulae for interpretation of electronic component performance and electrical measurement

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 13: pH and Redox

OPERATIONS

KNOWLEDGE

3. Servicing pH and Redox
measuring systems (cont'd)

(aa) Science:

- (i) oxidation
- (ii) reduction
- (iii) acids, bases, and salts
- (iv) pH scale
- (v) electrolysis
- (vi) type of lubricants and their
uses
- (vii) organic solvents and acids
- (viii) systems, units and techniques
of measurement
- (ix) electricity
- (x) electronics
- (xi) linkages and levers
- (xii) mechanical drives

AN ANALYSIS OF THE INDUSTRAIL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 14: Electrical conductivity and Dielectric Constant

OPERATIONS	KNOWLEDGE
1. Installing electrical conductivity and dielectric constant measuring systems	<ul style="list-style-type: none">(a) Interpretation of drawings, specifications and manufacturer's instructions to determine:<ul style="list-style-type: none">(i) components(ii) location(iii) circuit layout, connections and power supply requirements(iv) piping and tube layout and connections(b) Adherence to relevant codes and regulations(c) Type of conductivity and dielectric measuring systems:<ul style="list-style-type: none">(i) portable and laboratory(ii) continuous process stream analysis(d) Principle components:<ul style="list-style-type: none">(i) sample conditioning devices(ii) conductivity and dielectric cells and temperature compensators (integral or separate)(iii) measuring and amplifying circuits(iv) data reduction and display devices(v) power supplies and oscillators(e) Methods of installing components(f) Considerations when locating cells to ensure:<ul style="list-style-type: none">(i) representative sampling(ii) total immersion(iii) avoidance of extremes of sample velocity and temperature change(iv) optimum positioning to avoid accumulation of air and solids(v) proximity to temperature compensation detection device(g) Methods of mounting components(h) Consideration when mounting components for:<ul style="list-style-type: none">(i) accessibility(ii) orientation(iii) facilities for cell removal from pressured pipes and vessels(i) Methods and purpose of mixing, filtering, cooling, condensing, de-aerating and regulating flow and pressure of sampled stream

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 14: Electrical Conductivity and Dielectric Constant

OPERATIONS

KNOWLEDGE

1. Installing electrical conductivity and dielectric constant measuring systems (cont'd)

- (j) Procedures for installing, leak testing and connecting pipe and tube
- (k) Procedures for identifying, connecting and testing electrical conductors
- (l) Considerations when installing signal conductors:
 - (i) effects of size and length to measurement
 - (ii) type and purpose of screening and grounding
- (m) Procedures for checking system and placing in operation
- (n) Type, care, use and storage of electrical test meters, tools and equipment
- (o) Mathematics -
 - linear measurement for layout
- (p) Science:
 - (i) Pascal's principle
 - (ii) heat transfer
 - (iii) pressure due to head
 - (iv) flow through pipes
 - (v) velocity
 - (vi) elementary circuitry
 - (vii) conductors and insulators
 - (viii) Ohm's law
 - (ix) voltmeters and ohmmeters
 - (x) electrostatics

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 16: Analytical Instruments

UNIT 14: Electrical Conductivity and Dielectric Constant

OPERATIONS	KNOWLEDGE
<hr/>	
2. Calibrating conductivity and dielectric measuring systems	<ul style="list-style-type: none">(a) Interpretation of manufacturer's literature and relevant handbooks to determine:<ul style="list-style-type: none">(i) theory of operation(ii) calibration procedures(iii) range and application(b) Type and purpose of calibration(c) Type, purpose, use and care of calibrating equipment:<ul style="list-style-type: none">(i) conductivity bridge testers(ii) decade simulators, R.C. and L.(iii) check resistors and capacitors(iv) standard reference solutions(v) thermometers(d) Procedures for calibrating readout devices(e) Methods of connecting and applying check resistors and capacitors, resistive, capacitive and inductive decade simulators(f) Effects of temperature compensation on calibration(g) Techniques of interpreting capacity, conductivity and temperature calibration curves and units of measurement(h) Techniques of adjusting zero, range and linearity(i) Procedures for calibrating cells(j) Importance of rinsing and platinizing cell electrodes before calibrating(k) Methods of connecting to calibrated bridge recorders, conductivity bridge testers and resistance and capacitance bridges(l) Preparation and use of standard reference solutions(m) Importance of correct immersion of cells and temperature detectors(n) Importance of allowing adequate time for cells and detectors to reach stability(o) Methods of setting and adjusting manual temperature compensating devices(p) Procedures for establishing, checking and adjusting cell constants(q) Significance of cell constant in conductivity measurement

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 14: Electrical Conductivity and Dielectric Constant

OPERATIONS

KNOWLEDGE

2. Calibrating conductivity and dielectric measuring systems (cont'd)

- (r) Techniques of interpreting solution dielectric constant, conductance and temperature curves
- (s) Methods of calculating scale multipliers for temperature referencing and cell constant compensation
- (t) Mathematics:
 - (i) graphs, percentage, powers, ratio and proportion to calculate calibrating values, adjustments and data readout
 - (ii) algebraic equations and formulae to establish cell constants and scale multipliers
- (u) Science:
 - (i) systems, units and techniques of measurement
 - (ii) heat transfer, temperature indicators and scales
 - (iii) theory of ionization
 - (iv) electrolysis
 - (v) specific resistance conductance and dielectric constant
 - (vi) electricity
 - (vii) electronics

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 14: Electrical Conductivity and Dielectric Constant

OPERATIONS	KNOWLEDGE
3. Servicing conductivity and dielectric measuring systems	<ul style="list-style-type: none"> (a) Interpretation of drawings, manufacturer's literature and relevant handbooks to determine: <ul style="list-style-type: none"> (i) operating principles (ii) application (iii) electrical circuit detail (iv) recommended routine maintenance and trouble-shooting procedures (v) spare parts (b) Purpose and function of conductivity and dielectric measuring systems and components (c) Type, use, construction material and characteristic of cells and temperature detectors (d) Type and purpose of cell holders and thermowells (e) Purpose and function of sample stream conditioning devices: <ul style="list-style-type: none"> (i) mixing orifices and baffles (ii) heat exchangers (iii) filters, traps and gas eliminators (iv) flow, pressure and temperature regulators and indicators (v) other (f) Purpose and function of measuring, data reduction and readout devices and components: <ul style="list-style-type: none"> (i) A.C. bridges, ohmmeters and L.C. circuits (ii) power supplies, transformers and rectifiers (iii) amplifiers and oscillators (iv) multipoint switches and relays (v) precision resistors and capacitors, potentiometers and slide-wires (vi) indicator scales and magic eye tubes (vii) recording and indicating galvanometers and frequency meters (viii) self-balancing mechanisms and motors (ix) chart and inking assemblies (x) other

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 14: Electrical Conductivity and Dielectric Constant

OPERATIONS

KNOWLEDGE

3. Servicing conductivity and dielectric measuring systems (cont'd)

- (g) Procedures for removing, repairing and replacing components
- (h) Techniques of recognizing and locating system malfunctions
- (i) Methods of inspecting cells for defects such as:
 - (i) foreign coatings on electrodes
 - (ii) lack of platinum black on electrodes
 - (iii) distortion or mal-spacing of electrodes
 - (iv) mechanical damage
 - (v) plugged vent holes in shield
 - (vi) other
- (j) Methods of dismantling, cleaning, drying, assembling and leak testing cells
- (k) Type and purpose of O-rings and seals
- (l) Type, use and hazard of organic acids
- (m) Procedures, materials and techniques for platinization of electrodes
- (n) Methods of cleaning, flushing and leak testing sample conditioning devices
- (o) Procedures for measuring and adjusting circuit parameters
- (p) Methods of checking electronic component performance and characteristics
- (q) Type, care and use of electrical test meters:
 - (i) V.O.M.
 - (ii) V.T.V.M.
 - (iii) frequency meters
 - (iv) tube testers
 - (v) bridges R.C. and L.
- (r) Methods of cleaning electrical contracting surfaces
- (s) Type, use and hazards of organic solvents
- (t) Methods of lubricating pivots, bearings and mechanical drives
- (u) Type and use of lubricants
- (v) Type, care and use of tools and equipment

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 14: Electrical Conductivity and Dielectric Constant

OPERATIONS

KNOWLEDGE

3. Servicing conductivity and dielectric measuring systems (cont'd)

(w) Mathematics:

- (i) metric measurement, percentage, ratio and proportion to calculate make-up of platinizing solutions
- (ii) graphs, algebraic equations and formulae to establish measurement of circuit parameters and component performance characteristics

(x) Science:

- (i) chemical formulae and equations
- (ii) conditioning of hard water
- (iii) electrolysis
- (iv) organic solvents and acids
- (v) Bernoullis' theorem
- (vi) systems, units and techniques of measurement
- (vii) fits and clearances
- (viii) mechanical drives
- (ix) electricity
- (x) electronics

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 15: Reaction Product

OPERATIONS

KNOWLEDGE

1. Installing reaction product analysers

- (a) Interpretation of drawings and manufacturer's literature to determine:
 - (i) components
 - (ii) location
 - (iii) tubing layout and connections
 - (iv) electrical circuit layout, connections, and power supply requirements
- (b) Importance of adherence to relevant codes and regulations
- (c) Type and purpose of reaction product measuring systems:
 - (i) amperometric
 - (ii) photometric
 - (iii) conductance
- (d) Installation considerations
- (e) Methods of unpacking and assembling components
- (f) Procedures for locating and mounting components
- (g) Considerations when mounting components for:
 - (i) accessibility
 - (ii) orientation
- (h) Methods of cleaning, installing, connecting, and leak testing metal, plastic, and glass tubing
- (i) Methods of installing, identifying, testing, and connecting electrical conductors and harnesses
- (j) Type, care, and use of electrical test meters
- (k) Considerations when preparing analyser for service
- (l) Methods and materials for charging sample filters, driers, and conditioners
- (m) Procedures and materials for preparing and installing electrolyte and reagent solutions
- (n) Methods of adding pump lubrication
- (o) Methods of installing tapes
- (p) Procedures for activating and checking analyser operation
- (q) Type, care and use of tools and equipment

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 15: Reaction Product

OPERATIONS	KNOWLEDGE
<hr/>	
1. Installing reaction product analysers (cont'd)	(r) Mathematics - linear measurement for layout (s) Science: (i) fits and clearances (ii) friction (iii) flow through pipes (iv) conductors and insulators (v) elementary circuitry (vi) ammeter, voltmeter, and ohmmeter

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 15: Reaction Product

OPERATIONS

KNOWLEDGE

2. Calibrating reaction product analysers

- (a) Interpretation of manufacturer's literature and relevant handbooks to determine:
 - (i) calibration procedures
 - (ii) application and range
 - (iii) standards of accuracy
- (b) Type, purpose, and method of calibration
- (c) Type, purpose, and composition of calibrating gases
- (d) Care and use of gas cylinders and sample bombs
- (e) Procedures for connecting and applying calibrating gases
- (f) Methods of adjusting flow, pressure and temperature of calibrating sample gases
- (g) Methods and importance of applying compensation considerations
- (h) Interpretation of graphs and tables
- (i) Techniques of interpreting data readout devices
- (j) Methods of adjusting zero, range, and linearity of analyser
- (k) Procedures for titrating solutions
- (l) Methods of checking and adjusting photometers using standard solutions and colour standards
- (m) Methods of checking and adjusting potentiometric, null balance, and bridge recorders
- (n) Type, care, and use of test equipment:
 - (i) portable potentiometers
 - (ii) impedance bridges
 - (iii) impedance decade boxes
- (o) Mathematics:
 - graphs, percentage, powers and roots, ratio and proportion, algebraic formulae and equations to calculate calibration values, compensations, adjustments, and interpret data readout

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 15: Reaction Product

OPERATIONS	KNOWLEDGE
<hr/>	
2. Calibrating reaction product analysers (cont'd)	(p) Science: <ul style="list-style-type: none">(i) gas laws(ii) Bernoullis' theorem(iii) preparation, properties, storage and use of gases(iv) percentage composition(v) systems, units, and techniques of measurement(vi) transmission, reflection refrac- tion, and absorption of light(vii) temperature indicators and scales(viii) electricity(ix) electronics

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 15: Reaction Product

OPERATIONS

KNOWLEDGE

3. Servicing reaction product analysers

- (a) Interpretation of drawings and manufacturer's manuals to determine:
 - (i) type, purpose, and function
 - (ii) operating principles
 - (iii) component types, materials, and construction
 - (iv) electrical circuit data
 - (v) suggested routine maintenance and repair procedures
 - (vi) recommended spare parts
- (b) Type of samples being analysed:
 - (i) gas
 - (ii) vapor
 - (iii) liquid
- (c) Type and purpose of sample system components:
 - (i) pumps, ejectors, and aspirators
 - (ii) filters, driers, scrubbers, conditioners, de-humidifiers, absorption columns, and heaters
 - (iii) flow, temperature, and pressure indicators and regulators
 - (iv) calibrated sample containers
 - (v) motors, agitators, and mixers
 - (vi) other
- (d) Type and purpose of detection components:
 - (i) electrolytic cells
 - (ii) photo cells, photomultiplier tubes, impregnated tapes and light sources
 - (iii) conductivity cells
 - (iv) other
- (e) Type and purpose of measuring, data reduction, control circuits, and components:
 - (i) potentiometric and null balance recorders and ammeters
 - (ii) calibrated burettes
 - (iii) bridges, amplifiers, and rectifiers
 - (iv) photometers
 - (v) temperature compensators
 - (vi) rheostats
 - (vii) motor drives and timers
 - (viii) regulated power supplies and batteries

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 15: Reaction Product

OPERATIONS	KNOWLEDGE
3. Servicing reaction product analysers (cont'd)	<ul style="list-style-type: none"> (f) Type, purpose, and characteristic of reagent and buffer solutions (g) Methods of introducing reagent and buffer solutions (h) Techniques in recognition and isolation of analyser faults (i) Procedures for removal, repair, test, and replacement of components (j) Methods and frequency of cleaning and replenishing filters, driers, scrubbers, and absorption columns (k) Techniques of cleaning and flushing cells electrodes, and sample containers (l) Care and techniques of cleaning optical systems (m) Methods of cleaning electrical contacts and slidewires (n) Type, care, and use of cleaning materials: <ul style="list-style-type: none"> (i) organic solvents (ii) organic acids (iii) detergents (iv) abrasives (o) Procedures for lubricating and inspecting for wear: <ul style="list-style-type: none"> (i) pivots and bearings (ii) drive mechanisms (p) Type, care, and use of lubricants (q) Procedures for re-platinizing conductivity cell electrodes (r) Type and method of replenishing electrolyte and re-agent solutions (s) Procedures for measuring and establishing electrical circuit and component values and performance (t) Type, care, use, and storage of electrical test meters (u) Type, care, and use of tools and equipment

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 15: Reaction Product

OPERATIONS	KNOWLEDGE
<hr/>	
3. Servicing reaction product analysers (cont'd)	(v) Mathematics: <ul style="list-style-type: none">(i) linear measurement for gapping contacts and electrodes(ii) percentage, ratio and proportion, weights and measures to calculate and prepare platinizing, re-agent and electrolytic solutions(iii) graphs, algebraic formulae and equations to determine electric measurements and electronic component performance characteristics (w) Science: <ul style="list-style-type: none">(i) chemical and physical properties and changes(ii) oxidation and reduction(iii) acids, bases, and salts(iv) pH scale(v) electrolysis(vi) type of lubricants and their uses(vii) organic solvents(viii) organic acids(ix) abrasive materials(x) optical instruments(xi) sources of light(xii) mechanical drives and friction(xiii) drying agents(xiv) electricity(xv) electronics

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 16: Polarography

OPERATIONS	KNOWLEDGE
<hr/>	
1. Installing polarograph analysing systems	<ul style="list-style-type: none">(a) Interpretation of drawings, specifications and manufacturer's manuals to determine:<ul style="list-style-type: none">(i) type and purpose(ii) components and accessories(iii) location(iv) assembly procedures(v) electrical connections and power supply requirements(b) Importance of adherence to relevant codes(c) Type and purpose of polarograph components and accessories(d) Unpacking, assembly and installation considerations(e) Importance of suitable location conditions with respect to:<ul style="list-style-type: none">(i) temperature(ii) humidity(iii) mechanical shock(iv) stray electromagnetic fields(v) good electrical grounding facilities(f) Procedures for locating and connecting recorders and polarograph control circuit units(g) Methods of installing electrical wiring harnesses(h) Techniques of identifying, connecting and testing conductors(i) Importance of establishing correct power supply(j) Methods of testing and installing dry cells with due regard to polarity(k) Care and use of electrical test meters(l) Type of cells and purification assemblies and procedures for their assembly(m) Methods of filling cells and reservoirs with miscellaneous fluids(n) Care, use and hazards of mercury(o) Type of electrodes, and methods of locating and connecting(p) Methods of cleaning and connecting flexible tubing and capillaries(q) Procedures for energizing, and testing for proper operation

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 16: Polarography

OPERATIONS	KNOWLEDGE
<hr/>	
1. Installing polarograph analysing systems (cont'd)	(r) Mathematics: <ul style="list-style-type: none">(i) linear measurement for determining capillary lengths and system layout(ii) cubic and metric measurement to determine quantities of cell fluids (s) Science: <ul style="list-style-type: none">(i) systems, units and techniques of measurement(ii) heat transfer(iii) humidity(iv) conductors and insulators(v) elementary circuitry(vi) dry cells(vii) voltmeter, ammeter and ohmmeter(viii) electromagnetism(ix) pressure due to head

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 16: Polarography

OPERATIONS	KNOWLEDGE
2. Servicing polarograph analysing systems	<ul style="list-style-type: none"> (a) Interpretation of electrical schematics, manufacturer's literature and relevant handbooks to determine: <ul style="list-style-type: none"> (i) type and function (ii) operating principles (iii) component construction and materials (iv) electrical circuit data (v) testing and servicing procedures (vi) recommended spare parts (b) Purpose and function of system components (c) Type, part and construction of polarographic cells (d) Techniques for determining serviceability of cells (e) Procedures for repairing and replacing cells, cell parts and fluids (f) Type, material and characteristic of indicator and reference electrodes (g) Importance of, and methods of checking, conductor and electrode electrical contact (h) Type and purpose of supporting electrolytes (i) Purpose and use of capillary tube in dropping mercury electrodes (j) Methods of adjusting mercury drop rate (k) Effects of contaminated mercury and dirty capillaries, and methods and materials for cleaning (l) Effects of moisture in the cell (m) Methods of cleaning glassware (n) Care, use and hazard of organic acids (o) Type and purpose of sample deoxygenating accessories and gases (p) Methods of purifying deoxygenating gases (q) Care, use and hazards of high pressure gases and gas cylinders

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 16: Polarography

OPERATIONS	KNOWLEDGE
2. Servicing polarograph analysing systems (cont'd)	<ul style="list-style-type: none">(r) Type and purpose of electric and electronic circuits, components, controls and measuring devices:<ul style="list-style-type: none">(i) amplifiers and converters(ii) resistors, switches, potentiometers, bridges and range attenuation circuits(iii) sensitivity, span, zero, and compensation controls(iv) voltmeters, galvanometers and self-balancing potentiometers(v) servomechanisms and drive motors(vi) regulated power supplies, dry cells and standard cells(vii) others(s) Procedures for testing, adjusting, repairing and replacing electric and electronic components(t) Techniques of measuring and checking for miscellaneous circuit and component values and conditions(u) Methods of calibrating and adjusting display devices(v) Techniques of interpreting readout(w) Care, use and storage of electrical test meters and equipment:<ul style="list-style-type: none">(i) V.O.M.(ii) V.T.V.M.(iii) oscilloscope(iv) megger(v) tube tester(vi) resistance and capacitance bridges and decade simulators(vii) portable potentiometers(x) Procedures for cleaning slidewires, wires and contacts(y) Methods of inspecting for wear, lubricating and cleaning mechanical components:<ul style="list-style-type: none">(i) pivots and bearings(ii) pulleys and gears(iii) clutches and cams(iv) other(z) Type, care, use, hazard and storage of organic solvents and lubricants

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 16: Analytical Instruments UNIT 16: Polarography

OPERATIONS	KNOWLEDGE
<hr/>	
2. Servicing polarograph analysing systems (cont'd)	(aa) care, use and storage of tools and equipment (bb) Science: (i) characteristics of solids, liquids and gases (ii) chemical properties and changes (iii) oxidation and reduction (iv) acids, bases and salts (v) electrolysis (vi) type of lubricants and uses (vii) storage and use of gases (viii) organic solvents and acids (ix) systems, units and techniques of measurement (x) heat transfer (xi) electricity (xii) electronics

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 17: Direct Acting Indicating and Recording Instruments

TABLE OF CONTENTS

UNIT 1: Electrical	Page 398
2: Mechanical (Motion Input)	405

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 17: Direct Acting Indicating UNIT 1: Electrical and Recording Instruments

OPERATIONS	KNOWLEDGE
<hr/>	
1. Installing electrical type direct acting indicating and recording instruments	<ul style="list-style-type: none">(a) Interpretation of drawings to determine:<ul style="list-style-type: none">(i) type and purpose of instrument(ii) type of mounting and connection(iii) location(iv) electrical power supply requirement(b) Interpretation of electrical and instrumentation standards and symbols(c) Type, purpose and application of instruments:<ul style="list-style-type: none">(i) indicating(ii) strip chart recording(iii) circular chart recording(iv) single and multipoint(d) Type, form, magnitude and application of actuating signals:<ul style="list-style-type: none">(i) voltage(ii) current(iii) resistance, inductance, capacitance(iv) thermo-electric E.M.F.(v) other(e) Type, principle of operation and application of movements:<ul style="list-style-type: none">(i) moving coil (galvanometer type)(ii) dynamometer(iii) moving iron(iv) hot wire(v) coil plus rectifier(f) Methods of mounting instruments:<ul style="list-style-type: none">(i) surface(ii) panel(iii) field(g) Importance of providing an access for maintenance and service(h) Procedures for cutting and drilling metal panels(i) Techniques in welding, brazing and soldering(j) Methods to connect input wires to the instrument(k) Procedures, purpose and effect of shielding signal input wires

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 17: Direct Acting Indicating UNIT 1: Electrical
and Recording Instruments

OPERATIONS

KNOWLEDGE

- | | |
|---|---|
| 1. Installing electrical type direct acting indicating and recording instruments (cont'd) | <ul style="list-style-type: none">(l) Techniques of installing wiring harness and connecting electrical components(m) Importance of checking electrical wiring for correct polarity prior to power connection(n) Type, and use of test equipment:<ul style="list-style-type: none">(i) portable potentiometer(ii) portable bridge circuit(iii) multimeter(iv) megger(o) Techniques of checking wiring for continuity, insulation and grounding(p) Procedures to provide and connect required electrical power supply for:<ul style="list-style-type: none">(i) chart drives(ii) measuring circuits, reference, etc.(iii) internal illumination(iv) alarm circuits(q) Importance of checking instrument for correct operation(r) Mathematics<ul style="list-style-type: none">linear and angular measurement for installation(s) Science:<ul style="list-style-type: none">(i) voltmeter-ammeter-ohmmeter(ii) physical properties of materials(iii) thermal expansion(iv) electro-magnetism, magnets(v) potentiometers and bridges(vi) torque, moments |
|---|---|

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 17: Direct Acting Indicating UNIT 1: Electrical
and Recording Instruments

OPERATIONS

KNOWLEDGE

- | | |
|---|---|
| 2. Calibrating and aligning electrical type, direct acting indicating and recording instruments | <ul style="list-style-type: none">(a) Interpretation of manufacturer's manuals and specifications to determine:<ul style="list-style-type: none">(i) type, principle of operation and use of instruments(ii) range and scale of the instrument(iii) calibration and alignment instructions(iv) circuit diagram and terminal connections(b) Type and purpose of calibration:<ul style="list-style-type: none">(i) shop(ii) field(c) Methods of checking instrument accuracy to recognized standards(d) Type, purpose and function of electrical circuits and components:<ul style="list-style-type: none">(i) electrical movements, magnets(ii) slide wires, rheostats, resistors(iii) capacitors and inductors(iv) standard cells, dry cells, and power supplies(v) oscillators and amplifiers(vi) electrical integrators(vii) electrical chart drives(viii) others(e) Techniques of aligning or calibrating electrical circuits and components(f) Type, purpose and function of mechanical components:<ul style="list-style-type: none">(i) springs, pivots, jewels, counter weights(ii) pens, pointers, stops(iii) gear trains and linkages(iv) chart drives, charts(v) dampening devices(vi) scales (dials)(vii) printing mechanisms, inks(viii) mechanical integrators(ix) others(g) Techniques of aligning or calibrating mechanical components |
|---|---|

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 17: Direct Acting Indicating UNIT 1: Electrical
and Recording Instruments

OPERATIONS

KNOWLEDGE

2. Calibrating and aligning electrical type, direct acting, indicating and recording instruments (cont'd)
- (h) Type, function and use of test equipment to calibrate instruments:
 - (i) potentiometer
 - (ii) Wheatstone bridge
 - (iii) resistance, capacitance, inductance decade boxes
 - (iv) reference standards
 - (v) calibration signal source
 - (vi) thermionic tube and semiconductor testers
 - (i) Methods of lifting pointers or pens in removing or changing charts or scales
 - (j) Techniques and equipment to change or correct:
 - (i) range, span, zero
 - (ii) scale, linearity, angularity
 - (k) Importance of adequate lubrication
 - (l) Importance to check instrument for correct operation
 - (m) Mathematics:
 - (i) ratios, angles for alignment
 - (ii) integration (summation)
 - (iii) graphs, scales
 - (n) Science:
 - (i) A.C. and D.C. theory
 - (ii) potentiometers and bridges
 - (iii) amplifiers and oscillators
 - (iv) voltmeter, ammeter, ohmmeter
 - (v) gears, mechanisms, linkages
 - (vi) lubricants and their uses
 - (vii) organic solvents

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 17: Direct Acting Indicating UNIT 1: Electrical and Recording Instruments

OPERATIONS	KNOWLEDGE
3. Repairing and servicing electrical type (direct acting) indicating and recording instruments	<ul style="list-style-type: none">(a) Interpretation of service manuals to determine:<ul style="list-style-type: none">(i) type and application of instrument(ii) range and accuracy(iii) suggested repair and lubrication techniques(iv) calibration instructions(v) electrical power requirement(vi) service conditions, explosive atmospheres(vii) ventilation or purging instruction(b) Methods for inspection of instruments for correct operation(c) Equipment and procedures to test for continuity, insulation, shielding and grounding(d) Procedures for isolating measuring instruments from control mechanisms or circuits(e) Type, purpose and use of organic cleaning solvents(f) Importance, care and adequate ventilation and fire protection when using organic solvents(g) Techniques of removing and changing charts(h) Type, purpose and function of electrical circuits and components:<ul style="list-style-type: none">(i) electrical movements, magnets(ii) standard cells, constant voltage supplies, batteries(iii) oscillators, amplifiers(iv) measuring circuits(v) electrical integrators(vi) thermionic tubes, semi conductors(vii) choppers, transformers, relays(viii) chart drives(i) Methods of repairing or replacing electrical circuits and components(j) Techniques of rewiring harnesses and reconnecting electrical components

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 17: Direct Acting Indicating UNIT 1: Electrical and Recording Instruments

OPERATIONS	KNOWLEDGE
3. Repairing and servicing electrical type (direct acting) indicating and recording instruments (cont'd)	<ul style="list-style-type: none">(k) Type, purpose and function of mechanical components:<ul style="list-style-type: none">(i) springs, pivots, jewels counter-weights(ii) pens, pointers, stops(iii) gear trains and linkages(iv) chart drives(v) dampening devices(vi) scales(vii) mechanical integrators(viii) others(l) Methods of replacing or repairing mechanical components(m) Techniques of using test equipment:<ul style="list-style-type: none">(i) voltmeter, ammeter, ohmmeter(ii) tube and transistor testers(iii) signal generators(iv) oscilloscope(n) Methods of testing for:<ul style="list-style-type: none">(i) continuity(ii) grounds and shorts(iii) phase and polarity(o) Ambient consideration(p) Importance of adhering to scheduled inspection and repair for proper operation(q) Methods of rewiring and connecting electrical components and techniques of applying heat sinks(r) Type, function and use of lubricants(s) Importance of checking instruments for correct function and operation(t) Mathematics:<ul style="list-style-type: none">(i) linear and angular measurement for assembly(ii) ratios(iii) basic trigonometrical functions for oscilloscope display

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 17: Direct Acting Indicating UNIT 1: Electrical
and Recording Instruments

OPERATIONS

KNOWLEDGE

3. Repairing and servicing
electrical type (direct
acting) indicating and
recording instruments (cont'd)

(u) Science:

- (i) A.C. & D.C. theory
- (ii) potentiometers and bridges
- (iii) voltmeter, ammeter, ohmmeter
- (iv) gears, mechanisms, linkages
- (v) torques and moments
- (vi) cathode ray tubes
- (vii) thermal emission
- (viii) thermionic tubes and semi-conductors
- (ix) lubricants and their uses
- (x) organic solvents

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 17: Direct Acting Indicating UNIT 2: Mechanical (Motion Input) and Recording Instruments

OPERATIONS	KNOWLEDGE
1. Installing mechanical type indicating and recording instruments	<ul style="list-style-type: none">(a) Interpretation of drawings to determine:<ul style="list-style-type: none">(i) type and purpose of instrument(ii) type of mounting(iii) location(b) Interpretation of electrical and instrumentation standards and symbols(c) Type, size and application of instruments:<ul style="list-style-type: none">(i) indicating and recording(ii) circular and stripchart recording(iii) single and multipoint(d) Type, function and application of actuating mechanisms(e) Methods of mounting instruments:<ul style="list-style-type: none">(i) surface(ii) panel(iii) field(f) Importance of providing an access for maintenance and service(g) Procedures for cutting and drilling metal panels(h) Techniques in welding, brazing and soldering(i) Type, purpose and application of:<ul style="list-style-type: none">(i) fittings(ii) brackets(iii) connectors(iv) shock pads and springs(j) Procedures for installation and connection of impulse signal lines or actuating mechanisms to the instrument(k) Techniques to test actuating mechanisms for proper operation(l) Methods to connect actuators to linkage mechanisms(m) Types, purpose and application of linkages(n) Importance of checking any electrical wiring for correct polarity prior to power connection(o) Methods to provide and connect required electrical power supply for:<ul style="list-style-type: none">(i) chart drives(ii) internal illumination(iii) alarm circuit

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 17: Direct Acting Indicating UNIT 2: Mechanical (Motion Input)
and Recording Instruments

OPERATIONS

KNOWLEDGE

1. Installing mechanical type
indicating and recording
instruments (cont'd)

- (p) Importance of checking instrument for
correct operation
- (q) Mathematics -
linear measurement for installation
- (r) Science:
 - (i) gears, mechanisms
 - (ii) physical properties of materials
 - (iii) voltmeter-ammeter-ohmmeter

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 17: Direct Acting Indicating UNIT 2: Mechanical (Motion Input)
and Recording Instruments

OPERATIONS

KNOWLEDGE

2. Calibrating and aligning
mechanical input type indicat-
ing and recording instruments

- (a) Interpretation of manufacturer's specifications to determine:
 - (i) type and function of the instrument
 - (ii) range of the instrument
 - (iii) linearity, scale
 - (iv) calibration and alignment instructions
- (b) Type of calibration:
 - (i) shop
 - (ii) field
- (c) Type, function and use of test equipment to calibrate the instrument
- (d) Procedures to test for leaks in impulse and connected lines
- (e) Methods of lifting pointers or pens in removing or changing charts
- (f) Type, function and application of linkages, gears and mechanisms
- (g) Techniques for adjustment of linkages and mechanisms to change or correct:
 - (i) span
 - (ii) range, zero
 - (iii) scale, linearity, angularity
- (h) Techniques for adjustment of pointers and pens for correct contact or pressure
- (i) Methods of positioning chart drives and scales
- (j) Type, principle of operation and techniques for adjustment and calibration of mechanical integrating mechanisms
- (k) Type, purpose and importance of adequate lubrication
- (l) Importance of checking an instrument for correct operation
- (m) Mathematics:
 - (i) ratios, roots, graphs for alignment and adjustment
 - (ii) linear and angular measurement for alignment
- (n) Science:
 - (i) springs, gears, linkages and mechanisms
 - (ii) Boyles and Charles Laws
 - (iii) lubricants and their uses

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 17: Direct Acting Indicating UNIT 2: Mechanical (Motion Input)
and Recording Instruments

OPERATIONS

KNOWLEDGE

3. Repairing and servicing
mechanical input type
indicating and recording
instruments

- (a) Interpretation of service manuals to determine:
 - (i) type and application of instrument
 - (ii) range and accuracy
 - (iii) suggested repair techniques
 - (iv) calibration instructions
 - (v) electrical power requirement
 - (vi) lubrication instructions
 - (vii) identification of spare parts
- (b) Methods for inspection of instruments for correct operation
- (c) Equipment and procedures to test for leaks
- (d) Procedures for isolating measuring instrument from control mechanisms
- (e) Type, purpose, care and use of organic cleaning solvents
- (f) Importance of adequate ventilation and fire protection when using organic solvents
- (g) Techniques of removing and changing charts
- (h) Procedures and equipment to inspect, replace or repair:
 - (i) actuating mechanisms
 - (ii) linkages and pivots
 - (iii) bearings and gears
 - (iv) printing and indicating mechanisms
 - (v) chart plate mechanisms
 - (vi) glass, case, hinges
- (i) Procedures to replace bent or damaged linkages and importance of subsequent recalibration
- (j) Methods, type and frequency of lubrication of instrument components
- (k) Importance of care and cleanliness while handling and servicing mechanical (motion input type) component parts
- (l) Procedure to service or replace printing components
- (m) Type, function and method of printing:
 - (i) ink reservoir, ink pads
 - (ii) pressure paper, chopper bar
 - (iii) sensitized paper

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 17: Direct Acting Indicating UNIT 2: Mechanical (Motion Input)
and Recording Instruments

OPERATIONS	KNOWLEDGE
<hr/>	
3. Repairing and servicing mechanical input type indicating and recording instruments	<ul style="list-style-type: none">(n) Type, function and application of chart drive mechanisms:<ul style="list-style-type: none">(i) electrical(ii) mechanical - spring driven(o) Techniques of rewiring and connecting electrical components:<ul style="list-style-type: none">(i) chart drives(ii) internal illumination(iii) alarm circuits(p) Methods of repairing or replacing electrical components(q) Techniques to repair or replace mechanical chart drive components(r) Mathematics:<ul style="list-style-type: none">(i) ratios, roots and powers for adjustment and alignment(ii) graphs, scales(iii) linear and angular measurements for assembly(s) Science:<ul style="list-style-type: none">(i) springs, gears, linkages(ii) mechanisms(iii) Boyles and Charles Laws(iv) lubricants and their uses(v) cleaning fluids, detergents(vi) voltmeter-ammeter-ohmmeter(vii) voltage, frequency

BLOCK 18: Indirect Acting (Servo-Operated)
Indicating and Recording Instrument Devices

TABLE OF CONTENTS

UNIT 1: Measuring Circuits	Page 411
2: Amplifiers	416
3: Servomechanisms	420
4: Chart Drive Mechanisms	424
5: Recording and Indicating Mechanisms	428

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 18: Indirect Acting (Servo- UNIT 1: Measuring Circuits
Operated) Indicating and
Recording Instrument Devices

OPERATIONS	KNOWLEDGE
1. Installing and adjusting measuring circuits	<ul style="list-style-type: none">(a) Interpretation of drawings and manufacturer's specifications to determine:<ul style="list-style-type: none">(i) type, function and application of measuring circuits(ii) range, sensitivity and linearity(iii) electrical connections and power requirements(iv) location and mounting instructions(v) recommended procedures for changing or adjusting range, span and zero suppression(b) Interpretation of instrumentation and electrical symbols and standards(c) Type, principle of operation and application of measuring circuits:<ul style="list-style-type: none">(i) D.C. potentiometers(ii) A.C. potentiometers(iii) D.C. bridges(iv) A.C. bridges(d) Procedures for installation and adjustment of measuring circuits(e) Importance of matching output impedance of the measured quantity to the input impedance of the measuring circuit(f) Type, function and application of servo-operated potentiometer and bridge circuit components:<ul style="list-style-type: none">(i) wire wound slide wire and wiper or strain gauge mechanism(ii) standard cell, dry batteries(iii) constant D.C. voltage supplies (regulated)(iv) constant A.C. voltage supplies (regulated)(v) standardizing mechanisms (rheostats and solenoid clutches)(vi) standardizing circuits(vii) ambient temperature compensating components(viii) wire wound high stability resistors(ix) constant and variable condensers and inductors(x) miscellaneous mechanical and electrical components

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 18: Indirect Acting (Servo- UNIT 1: Measuring Circuits
Operated) Indicating and
Recording Instrument Devices

OPERATIONS	KNOWLEDGE
<hr/>	
1. Installing and adjusting measuring circuits (cont'd)	<ul style="list-style-type: none">(g) Methods of installation and adjustment of potentiometer and bridge circuit components(h) Type, function and use of test equipment to calibrate, or check potentiometer or bridge circuits:<ul style="list-style-type: none">(i) D.C. and A.C. portable potentiometers(ii) oscillators(iii) D.C. and A.C. portable bridge circuits(iv) decade boxes (R, L, C)(v) multimeter(vi) oscilloscope(vii) V.T.V.M.(viii) D.C. voltage source(i) Techniques to change or correct for:<ul style="list-style-type: none">(i) range, span(ii) zero suppression(j) Importance of keeping circuit components such as slide wires etc., free from dust and corrosive atmosphere(k) Techniques of installing wiring harness and connecting electrical components(l) Type, purpose and technique of shielding(m) Effect of stray signals on measurement(n) Methods and equipment to solder or braze instrument components(o) Type, function and application of heat sinks(r) Techniques of testing circuits for continuity, insulation, grounding and correct polarity prior to connection to other components and power supply(q) Importance of checking measuring circuit for correct operation(r) Mathematics:<ul style="list-style-type: none">(i) linear and angular measurement for installation and layout(ii) trigonometrical functions to interpret wave-forms(iii) ratios, roots, powers for adjustment

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 18: Indirect Acting (Servo- UNIT 1: Measuring Circuits
Operated) Indicating and
Recording Instrument Devices

OPERATIONS

KNOWLEDGE

- | | |
|--|--|
| 1. Installing and adjusting
measuring circuits (cont'd) | (s) Science: <ul style="list-style-type: none">(i) electricity(ii) insulators and conductors(iii) A.C. and D.C. circuits(iv) A.C. and D.C. potentiometers
and bridges(v) thermionic tubes and semi-
conductors(vi) ammeter-voltmeter-ohmmeter(vii) cathode ray tubes |
|--|--|

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 18: Indirect Acting (Servo- UNIT 1: Measuring Circuits
Operated) Indicating and
Recording Instrument Devices

OPERATIONS	KNOWLEDGE
<hr/>	
2. Repairing and servicing measuring circuits	<ul style="list-style-type: none">(a) Interpretation of service manuals to determine:<ul style="list-style-type: none">(i) type and function of measuring circuits(ii) calibration, range and accuracy(iii) electrical power requirement(iv) suggested repair, lubrication and servicing procedures(v) recommended procedures to change range or zero of instrument(b) Service considerations(c) Methods of inspection of measuring circuits for correct operation(d) Equipment and procedures to test measuring circuits and associated components for continuity, insulation, grounds and stray signals(e) Type, purpose, care and use of organic cleaning solvents(f) Techniques of cleaning sliding components (contacts)(g) Importance of adequate ventilation and fire protection when using organic solvents(h) Type, purpose and use of lubricants(i) Importance of cleanliness while handling measuring circuit components(j) Type and function of servo-operated potentiometer and bridge measuring circuit components:<ul style="list-style-type: none">(i) slide wires and strain gauge mechanisms(ii) standard cell, dry batteries(iii) regulated D.C. and A.C. power supplies(iv) standardizing mechanisms and circuits(v) ambient conditions compensating circuits and components(vi) high stability resistors, condensers and inductors (constant and variable)(vii) miscellaneous mechanical and electrical components

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 18: Indirect Acting (Servo- UNIT 1: Measuring Circuits
Operated) Indicating and
Recording Instrument Devices

OPERATIONS

KNOWLEDGE

2. Repairing and servicing measuring circuits (cont'd)
- (k) Methods of replacement, repair, lubrication and servicing of servo-operated potentiometer and bridge measuring circuit components
 - (l) Importance of adhering to scheduled inspection and servicing measuring circuits for proper operation
 - (m) Methods of rewiring and connecting electrical components and techniques of soldering, brazing and applying heat sinks
 - (n) Type, function and use of test instruments:
 - (i) D.C. and A.C. portable potentiometers and bridges
 - (ii) oscillators
 - (iii) multimeters
 - (iv) decade boxes (R,L,C)
 - (v) oscilloscope
 - (vi) V.T.V.M.
 - (vii) regulated power supplies
 - (o) Procedures to use test instruments to check measuring circuits
 - (p) Importance of checking measuring circuits for correct function and operation
 - (q) Mathematics:
 - (i) linear and angular measurement for assembly
 - (ii) trigonometrical functions for wave-forms
 - (iii) ratios, roots, powers for checking calibration
 - (r) Science:
 - (i) electricity
 - (ii) A.C. and D.C. potentiometers and bridges
 - (iii) thermionic tubes and semi-conductors
 - (iv) ammeter-voltmeter-ohmmeter
 - (v) cathode ray tubes
 - (vi) lubricants and their uses
 - (vii) organic solvents

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 18: Indirect Acting (Servo- UNIT 2: Amplifiers
Operated) Indicating and
Recording Instrument Devices

OPERATIONS	KNOWLEDGE
<hr/>	
1. Installing and adjusting amplifiers	<ul style="list-style-type: none">(a) Interpretation of drawings and manufacturer's specifications to determine:<ul style="list-style-type: none">(i) type, function and application of amplifier(ii) gain, stability, frequency response and linearity(iii) electrical connection and power requirement(iv) input and output requirements(v) recommended procedures for gain adjustment(b) Interpretation of electrical and instrumentation standards specifications and symbols(c) Type, principle of operation and application of servo-amplifiers:<ul style="list-style-type: none">(i) D.C. thermionic(ii) D.C. semiconductor(iii) magnetic(iv) A.C., chopper type(d) Methods of installation and adjustment of servo-amplifiers(e) Procedures for fabrication of support brackets(f) Methods of cutting, drilling and tapping metal and plastic sheets(g) Techniques to install wiring harness and connecting electrical components(h) Type, purpose and technique of shielding(i) Effect of stray pick up signals on output(j) Methods and equipment to solder or braze amplifier components(k) Method, equipment and importance of testing wiring for insulation, continuity and grounds prior to power connections(l) Procedure for connection of amplifier input to potentiometer or bridge circuits(m) Type and method of connection of amplifier output to servo-motors or operators(n) Procedures, components and equipment to connect amplifiers to appropriate power supply

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 18: Indirect Acting (Servo- UNIT 2: Amplifiers
Operated) Indicating and
Recording Instrument Devices

OPERATIONS

KNOWLEDGE

1. Installing and adjusting
amplifiers (cont'd)

- (o) Importance of protecting amplifiers against mechanical damage and electrical overloads
- (p) Importance of checking amplifiers for correct operation
- (q) Mathematics:
 - (i) linear and angular measurements for layout
 - (ii) ratios, roots and powers for adjustment
- (r) Science:
 - (i) electricity
 - (ii) Ohm's Law, input and output impedance
 - (iii) A.C. and D.C. circuits
 - (iv) amplifiers
 - (v) conductors and insulators
 - (vi) heat transfer and heat sinks

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 18: Indirect Acting (Servo- UNIT 2: Amplifiers
Operated) Indicating and
Recording Instrument Devices

OPERATIONS	KNOWLEDGE
<hr/>	
2. Repairing and servicing amplifiers	<ul style="list-style-type: none">(a) Interpretation of service manuals to determine:<ul style="list-style-type: none">(i) type and function of amplifier(ii) gain, response, stability, accuracy and linearity(iii) electrical power requirements(iv) suggested repair and servicing procedures(v) recommended spare part and procedures for replacement of amplifier components(vi) suggested step by step troubleshooting and repair procedures(b) Service considerations(c) Methods and equipment to test amplifiers for correct function and operation(d) Type, function and use of amplifier components:<ul style="list-style-type: none">(i) vibration and semiconductor type invertors(ii) power and audio transformers(iii) chokes, capacitors, resistors (variable and fixed)(iv) thermionic tubes(v) semiconductors(vi) wires, cables, insulators(vii) plugs, bases, terminals, connectors(viii) pilot lights, switches(ix) miscellaneous electrical and mechanical components(e) Procedures and equipment to check, clean and replace or repair amplifier components(f) Type, function and use of test equipment and standards:<ul style="list-style-type: none">(i) multimeter(ii) V.T.V.M.(iii) signal generators(iv) oscilloscope(v) tube and semiconductor tester(g) Importance of availability of correct power supply(h) Methods of testing procedures in carrying out a frequency response test analysis on amplifiers

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 18: Indirect Acting (Servo- UNIT 2: Amplifiers
Operated) Indicating and
Recording Instrument Devices

OPERATIONS

KNOWLEDGE

2. Repairing and servicing
amplifiers (cont'd)

- (i) Procedures in testing amplifiers for insulation, ground and shielding
- (j) Importance of adhering to scheduled inspection, servicing and replacement of components
- (k) Methods of rewiring, soldering or brazing electrical components
- (l) Techniques for installing wiring harness and connecting it to electrical components
- (m) Importance of testing amplifiers for correct operation in conjunction with its associated equipment
- (n) Mathematics:
 - (i) linear and angular measurements for assembly
 - (ii) trigonometric functions to interpret wave-forms
 - (iii) ratios, roots, powers
 - (iv) plotting graphs of frequency response (Bode diagrams)
 - (v) logarithms
- (o) Science:
 - (i) A.C. and D.C. circuits
 - (ii) electricity
 - (iii) thermionic tubes and semi-conductors
 - (iv) conductors and insulators
 - (v) cathode ray tubes
 - (vi) voltage and power amplifiers and oscillators
 - (vii) inductors and transformers
 - (viii) ammeter-voltmeter-ohmmeter
 - (ix) solders, fluxes and solvents
 - (x) heat transfer, heat sinks

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 18: Indirect Acting (Servo- UNIT 3: Servomechanisms
Operated) Indicating and
Recording Instrument Devices

OPERATIONS	KNOWLEDGE
<hr/>	
1. Installing and aligning servomechanism components	<ul style="list-style-type: none">(a) Interpretation of drawings and manufacturer's specifications to determine:<ul style="list-style-type: none">(i) type, purpose and function of the system(ii) alignment instructions(iii) electrical power requirement(iv) pneumatic or hydraulic supplies(v) operating power, torque, ratio and speed(b) Interpretation of electrical and instrumentation standards and symbols(c) Service conditions(d) Type, purpose and function of mechanical servo-components:<ul style="list-style-type: none">(i) gears, gear trains(ii) linkages(iii) cable drives, chains, belts couplings(iv) cams and followers(v) pneumatic motors and operators(vi) hydraulic motors and operators(vii) feedback mechanisms(viii) damping mechanisms(ix) shafts and bearings(e) Methods of mounting and alignment of mechanical servo-components(f) Type, purpose and function of electrical circuits and components:<ul style="list-style-type: none">(i) motors(ii) solenoids(iii) A.C. self-synchronous motors, positioners, regulators(iv) tachogenerators(v) miscellaneous electrical components(g) Techniques of installation and alignment of electrical circuits and components(h) Techniques of installing wiring harness and connecting electrical components(i) Procedures for cutting and drilling metal sheets(j) Techniques in welding, brazing and soldering(k) Techniques and test equipment to check electrical wiring for continuity, insulation and grounding

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 18: Indirect Action (Servo- UNIT 3: Servomechanisms
Operated) Indicating and
Recording Instrument Devices

OPERATIONS

KNOWLEDGE

1. Installing and aligning
servomechanism components
(cont'd)

- (l) Methods and importance of correct alignment of mechanical and electrical servo-components
- (m) Effect of backlash and friction on servo-operation
- (n) Importance of checking the system for correct polarity and direction of rotation prior to connection to electrical and mechanical power supply
- (o) Type, application and method of connection of appropriate power supply
- (p) Importance of checking the system for correct operation
- (q) Mathematics -
 - linear and angular measurement for installation
- (r) Science:
 - (i) A.C. and D.C. circuits
 - (ii) electro-magnetism
 - (iii) EMF-Generation
 - (iv) transformers
 - (v) rectifiers
 - (vi) amplifiers
 - (vii) torque and moments
 - (viii) cams

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 28: Indirect Action (Servo- UNIT 3: Servomechanisms
Operated) Indicating and
Recording Instrument Devices

OPERATIONS	KNOWLEDGE
2. Repairing and servicing servomechanism components	<ul style="list-style-type: none">(a) Interpretation of service manuals to determine:<ul style="list-style-type: none">(i) type, function and application of the system(ii) range and sensitivity(iii) suggested repair and lubrication techniques(iv) power requirements(v) service conditions (explosive atmospheres)(vi) ventilation or purging instructions(b) Procedures and test equipment to check servo-components for correct operation(c) Type, function and application of mechanical servo-components<ul style="list-style-type: none">(i) gear trains(ii) linkages(iii) cable drives, belts, chains, shafts, couplings and bearings(iv) cams and cam followers(v) pneumatic and hydraulic motors and operators(vi) damping mechanisms(vii) feedback mechanisms(d) Techniques of replacement, repair and service of mechanical servo-components(e) Type, function and application of electrical servo-components and circuits:<ul style="list-style-type: none">(i) motors(ii) solenoids(iii) tachogenerators(iv) rectifiers, transformers(v) saturable core reactors(vi) contactors, relays, switches(f) Procedures for replacement, repair and service of electrical servo-components and circuits(g) Methods of rewiring and connecting electrical components and techniques of applying heat sinks(h) Type, purpose and use of organic solvents(i) Importance of adequate ventilation and fire protection when using organic solvents

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 18: Indirect Action (Servo- UNIT 3: Servomechanisms
Operated) Indicating and
Recording Instrument Devices

OPERATIONS

KNOWLEDGE

2. Repairing and servicing
servomechanism components

- (j) Type, function and use of lubricants
- (k) Procedures for using test equipment:
 - (i) voltmeter, ammeter, ohmmeter
 - (ii) tube and semiconductor testers
 - (iii) oscilloscope
- (l) Importance of checking instruments for correct function and operation
- (m) Mathematics:
 - (i) linear and angular measurements for assembly
 - (ii) trigonometrical functions for alignment
- (n) Science:
 - (i) A.C. and D.C. circuits
 - (ii) electro-magnetism
 - (iii) dynamics of fluids
 - (iv) friction
 - (v) lubricants and their uses
 - (vi) ammeter-voltmeter-ohmmeter
 - (vii) cathode ray tubes
 - (viii) thermionic tubes and semi-conductors
 - (ix) organic solvents
 - (x) torque and movements

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 18: Indirect Acting (Servo- UNIT 4: Chart Drive Mechanisms
Operated) Indicating and
Recording Instrument Devices

OPERATIONS	KNOWLEDGE
<hr/>	
1. Installing and aligning chart drive mechanisms	<ul style="list-style-type: none">(a) Interpreting drawings and manufacturer's specifications to determine:<ul style="list-style-type: none">(i) type, function and application of chart drives(ii) alignment instructions(iii) electrical power requirements(iv) mechanical power requirements(v) location, mounting(b) Interpretation of instrumentation and electrical standards and symbols(c) Service considerations(d) Type of chart drive mechanisms:<ul style="list-style-type: none">(i) strip chart type(ii) circular chart type(e) Type and function of chart drives:<ul style="list-style-type: none">(i) electrical motor (constant speed drive)(ii) pneumatic motor (constant speed drive)(iii) spring driven (constant speed drive)(iv) servo-motor driven (function of measured variable)(f) Type and function of mechanical chart drive components:<ul style="list-style-type: none">(i) gear trains(ii) chains, linkages, belts, springs(iii) drive shafts and bearings(iv) couplings and clutches(v) timing mechanisms(vi) charts(vii) pneumatic motors(viii) spring drive mechanisms(ix) loading spindles(x) feedroll guide pins(xi) chart drive plates(g) Procedures for installation and alignment of mechanical chart drive components(h) Type, function and application of electrical chart drive components:<ul style="list-style-type: none">(i) motors and servo-motors(ii) solenoids(iii) relays(iv) micro-switches, toggle switches(v) electro-magnetic clutches

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 18: Indirect Acting (Servo- UNIT 4: Chart Drive Mechanisms
Operated) Indicating and
Recording Instrument Devices

OPERATIONS

KNOWLEDGE

1. Installing and aligning
chart drive mechanisms
(cont'd)

- (i) Procedures for installation, wiring and adjustment of electrical chart drive components
- (j) Techniques of installing wiring harness and connecting electrical components
- (k) Techniques for drilling, tapping and fabricating brackets, spacers and supports
- (l) Procedures for applying heat sinks in soldering and brazing operations
- (m) Importance of cleanliness when handling chart drive components
- (n) Techniques and equipment to change or correct speed of chart drives
- (o) Importance of correct alignment of chart drive components
- (p) Effect of friction and backlash on operations
- (q) Importance of checking chart drive system for correct polarity, direction of movement, insulation and grounding prior to connection to power supply
- (r) Techniques of feeding chart paper into the chart drive mechanism
- (s) Type, application and method of connection of appropriate power supply
- (t) Importance of checking chart drive system for correct operation
- (u) Mathematics:
 - (i) linear measurement for installation
 - (ii) ratios
- (v) Science:
 - (i) friction, damping
 - (ii) ammeter-voltmeter-ohmmeter
 - (iii) A.C. and D.C. circuits
 - (iv) electro-magnetism
 - (v) gear trains
 - (vi) vibration, oscillations
 - (vii) torque and movement

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 18: Indirect Acting (Servo- UNIT 4: Chart Drive Mechanisms
Operated) Indicating and
Recording Instrument Devices

OPERATIONS

KNOWLEDGE

2. Repairing and servicing
chart drive mechanisms

- (a) Interpretation of service manuals to determine:
 - (i) type, function and application of the chart drive
 - (ii) suggested repair and lubrication procedures
 - (iii) calibration or spot check instructions
 - (iv) electrical and mechanical power requirement
 - (v) service conditions
 - (vi) chart changing instructions
- (b) Method and equipment to inspect chart drives for correct operation
- (c) Procedures and frequency of changing charts
- (d) Importance of notifying process personnel when adjusting, checking or changing charts
- (e) Type, purpose and use of organic cleaning solvents
- (f) Importance of adequate ventilation and fire protection when using organic solvents
- (g) Type, function and application of mechanical chart drive components:
 - (i) gear trains
 - (ii) chains, linkages, belts, springs
 - (iii) shafts and bearings
 - (iv) couplings and clutches
 - (v) timing mechanisms
 - (vi) pneumatic motors
 - (vii) spring driven mechanisms
 - (viii) loading spindles
 - (ix) feedroll guide pins
 - (x) chart drive plates
- (h) Methods for replacement of repair and lubrication of mechanical chart drive components

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 18: Indirect Acting (Servo- UNIT 4: Chart Drive Mechanisms
Operated) Indicating and
Recording Instrument Devices

OPERATIONS

KNOWLEDGE

2. Repairing and servicing
chart drive mechanisms
(cont'd)

- (i) Type, function and application of electrical chart drive components:
 - (i) motors
 - (ii) solenoids
 - (iii) relays
 - (iv) micro-switches, toggle switches
 - (v) electro-magnetic clutches and brakes
 - (vi) miscellaneous components
- (j) Methods to test, replace and repair electrical chart drive components
- (k) Methods of rewiring and connecting electrical components
- (l) Importance of adhering to scheduled inspection and repair for proper operation
- (m) Importance of testing chart drive mechanisms for correct operation
- (n) Mathematics:
 - (i) linear and angular measurement
 - (ii) ratios
- (o) Science:
 - (i) friction, damping
 - (ii) lubricants and their uses
 - (iii) vibrations, oscillation
 - (iv) gear trains
 - (v) Charles and Boyles Laws
 - (vi) A.C. and D.C. circuits
 - (vii) electro-magnetism
 - (viii) torque and moments
 - (ix) organic solvents

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 18: Indirect Acting (Servo- UNIT 5: Recording and Indicating Mechanisms
Operated) Indicating and
Recording Instrument Devices

OPERATIONS	KNOWLEDGE
1. Installing and aligning recording and indicating mechanisms	<ul style="list-style-type: none">(a) Interpretation of drawings and manufacturer's specifications to determine:<ul style="list-style-type: none">(i) type function and application of mechanism(ii) aligning instructions(iii) electrical power requirements(iv) location(b) Interpretation of electrical and instrumentation symbols and standards(c) Service conditions(d) Type, function and application of indicating mechanisms:<ul style="list-style-type: none">(i) digital, mechanical(ii) digital, electrical(iii) dial, pointer type(e) Type, function and use of components in indicating systems:<ul style="list-style-type: none">(i) gears, gear trains, ratchets(ii) selector switch mechanisms(iii) linkages and cams(iv) pointers(v) square root extractors, integrators(vi) counters(f) Methods of installation and alignment of indicating mechanisms and components(g) Type, function and application of recording systems and components:<ul style="list-style-type: none">(i) continuous writing pens(ii) multipoint printing(iii) pen and printwheel carriage(iv) gears, gear trains, ratchets, rack and pinions(v) cable drives, shafts, couplings and bearings(vi) cams, linkages, levers(vii) ink reservoirs and pads(viii) solenoid actuated printers and clutches(ix) selector switch mechanisms(x) square root extractors and integrators(xi) counters

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 18: Indirect Acting (Servo- UNIT 5: Recording and Indicating Mechanisms
Operated) Indicating and
Recording Instrument Devices

OPERATIONS

KNOWLEDGE

1. Installing and aligning
recording and indicating
mechanisms (cont'd)

- (h) Methods of installation and alignment of recording systems and components
- (i) Effect of backlash and friction on indication and recording
- (j) Techniques of installing and wiring harness and connecting electrical components
- (k) Procedures for cutting, drilling and tapping metal and plastic sheets
- (l) Techniques of brazing and soldering
- (m) Methods and importance of correct alignment of printing and indicating components
- (n) Importance of recalibration after installation or adjustment of indicating or recording mechanisms
- (o) Type, application and method of connection of appropriate power supply
- (p) Importance of checking indicating and recording mechanisms for correct operation
- (q) Mathematics:
 - (i) linear and angular measurement for assembly
 - (ii) ratios and powers for alignment
- (r) Science:
 - (i) friction, damping
 - (ii) ammeter-voltmeter-ohmmeter
 - (iii) A.C. and D.C. circuits
 - (iv) conductors and insulators
 - (v) thermal conductivity
 - (vi) torque and moments

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 18: Indirect Acting (Servo- UNIT 5: Recording and Indicating Mechanisms
Operated) Indicating and
Recording Instrument Devices

OPERATIONS

KNOWLEDGE

2. Repairing and servicing
recording and indicating
mechanisms

- (a) Interpretation of service manuals to determine:
 - (i) type and operation of indicating and recording mechanisms
 - (ii) suggested repair and lubrication procedures
 - (iii) electrical power requirement
 - (iv) pen changing instructions
 - (v) ink and ink pads changing instructions
- (b) Methods and equipment to inspect indicating, recording and printing mechanisms for correct operation
- (c) Procedures and frequency of changing ink and ink pads
- (d) Type, purpose and use of organic cleaning solvents
- (e) Importance of adequate ventilation and fire protection when using organic solvents
- (f) Type and function of indicating and recording mechanisms and components:
 - (i) pens, pointers, dials, print wheel carriage
 - (ii) gears, ratchets, racks and pinions
 - (iii) shafts, couplings, cable drives, bearings
 - (iv) ink reservoir and ink pads
 - (v) solenoid printers and clutches
 - (vi) square root extractors and integrators
 - (vii) counters
 - (viii) cams, levers, linkages
 - (ix) others
- (g) Methods for inspecting, replacing, lubricating, repairing and adjusting indicating and recording mechanisms and components
- (h) Methods of replacing wiring harness and connecting electrical components
- (i) Procedures and frequency of lubrication of indicating and recording mechanisms and components

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 18: Indirect Acting (Servo- UNIT 5: Recording and Indicating Mechanisms
Operated) Indicating and
Recording Instrument Devices

OPERATIONS

KNOWLEDGE

2. Repairing and servicing
recording and indicating
mechanisms (cont'd)

- (j) Importance of checking recording and
indicating mechanism for correct opera-
tion
- (k) Mathematics:
 - (i) linear and angular measurement
for assembly
 - (ii) roots and powers
- (l) Science:
 - (i) friction, damping
 - (ii) viscosity, density
 - (iii) capillary effect (for ink
reservoir)
 - (iv) ammeter-voltmeter-ohmmeter
 - (v) lubricants and their uses
 - (vi) thermal conductivity
 - (vii) organic solvents
 - (viii) torque and moments

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE
. MEASUREMENT .

BLOCK 19: Pneumatic Signal Transmission Systems

TABLE OF CONTENTS

UNIT 1: Transmitters	Page 433
2: Receivers	441

. MEASUREMENT .

BLOCK 19: Pneumatic Signal
Transmission Systems

UNIT 1: Transmitters

OPERATIONS

KNOWLEDGE

1. Installing transmitters

- (a) Interpretation of drawings and specifications to determine:
 - (i) function
 - (ii) location
 - (iii) mounting details
 - (iv) service connections
 - (v) transmission connections
 - (vi) schematics and flowsheets of system
- (b) Interpretation of manufacturer's literature to determine:
 - (i) principle of operation
 - (ii) details of operation and assembly
 - (iii) adjustments
 - (iv) limits of ambient conditions
 - (v) recommendations for mounting and connecting
 - (vi) pressure range
 - (vii) overrange limits
- (c) Classes of pneumatic transmitters:
 - (i) unrestrained motion
 - (ii) restrained motion (motion balance)
 - (iii) force balance
- (d) Type, principle and method of installing pneumatic transmitters for measuring:
 - (i) position
 - (ii) temperature
 - (iii) pressure
 - (iv) differential pressure
 - (v) level
 - (vi) flow
 - (vii) specific gravity
 - (viii) viscosity
 - (ix) consistency
 - (x) others
- (e) Methods of mounting transmitters
- (f) Importance of checking function and calibration of transmitter
- (g) Type and use of sealing fluids and chambers
- (h) Procedures for filling sensing lines with sealing fluids

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 19: Pneumatic Signal
Transmission Systems

UNIT 1: Transmitters

OPERATIONS	KNOWLEDGE
<hr/>	
1. Installing transmitters	<ul style="list-style-type: none">(i) Methods of relieving air in liquid filled sensing lines(j) Type, principle and method of installing pulsation dampeners(k) Type, use and method of installing capillaries(l) Care, use and methods of installing permanent magnet position sensing rods(m) Use of transmitters as controllers(n) Use of valve positioners as motion transmitters(o) Mathematics:<ul style="list-style-type: none">(i) linear, square and cubic measurement for layout and installation(ii) formula to calculate electrical values(p) Science:<ul style="list-style-type: none">(i) pneumatics(ii) fluid flow through pipes, tubes, orifices(iii) levers and mechanical advantage(iv) spring rate(v) torque and torsion(vi) magnetic properties(vii) tension and compression

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 19: Pneumatic Signal
Transmission Systems

UNIT 1: Transmitters

OPERATIONS

KNOWLEDGE

2. Calibrating transmitters

- (a) Interpretation of drawings and specifications to determine:
 - (i) function
 - (ii) type and range of primary element
 - (iii) calibration procedures
 - (iv) fluid pressure and temperature
- (b) Interpretation of manufacturer's literature to determine:
 - (i) type and principle of operation
 - (ii) adjustment details
 - (iii) sealing fluid requirements
 - (iv) recommended procedures for calibration
 - (v) accuracy limits
 - (vi) assembling details
- (c) Type, purpose and limit of measuring elements used with pneumatic transmitters:
 - (i) bourdon springs
 - (ii) bellows
 - (iii) bellows and spring combinations
 - (iv) diaphragms
 - (v) moving permanent magnets
 - (vi) floats
 - (vii) bells (floats)
 - (viii) mechanical linkages and cams
 - (ix) others
- (d) Type, use and care of test equipment for shop or in-plant testing and calibration:
 - (i) primary standards
 - (ii) secondary standards
- (e) Methods of making test connections to transmitter:
 - (i) air supply
 - (ii) measurement variable
 - (iii) output
- (f) Importance of specifications for air supply pressure and overrange values
- (g) Procedures for making initial mechanical alignment of moving parts
- (h) Methods of converting from circular motion (arc of travel) to linear motion
- (i) Effects of incorrect angles between linkages

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 19: Pneumatic Signal
Transmission Systems

UNIT 1: Transmitters

OPERATIONS	KNOWLEDGE
<hr/>	
2. Calibrating transmitters	<ul style="list-style-type: none">(j) Methods of adjusting nozzle baffle relationship(k) Methods of measuring and adjusting nozzle pressure(l) Methods of calibrating nozzle relays or booster relays(m) Procedures and adjustments for:<ul style="list-style-type: none">(i) zero(ii) range(iii) span(iv) linearity(n) Importance and methods of adjusting precision balance of multiple bellows and beams(o) Procedures for performing wet and dry calibrations(p) Methods of checking and adjusting measurement lag compensating devices(q) Importance of checking and calibrating the input - output relationship of the transmitter at a minimum of three points(r) Methods of adjusting indicating pointers or recording pens and their linkages(s) Procedures for calibrating and checking spool-type pilot valve transmitters(t) Methods of testing and calibrating pneumatic square root extractors or other linearizing devices(u) Use of precision linear measuring tools(v) Importance of recording the "as found" and "as left" conditions(w) Mathematics:<ul style="list-style-type: none">(i) linear measurement(ii) ratio and proportion(iii) powers and roots(iv) percentages(v) circles, arcs and angles(vi) graphs, simple and equations

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 19: Pneumatic Signal
Transmission Systems

UNIT 1: Transmitters

OPERATIONS

KNOWLEDGE

2. Calibrating transmitters
(cont'd)

(x) Science:

- (i) levers and mechanical advantage
- (ii) spring rate
- (iii) torque and torsion
- (iv) air flow through small jets and restrictions
- (v) magnetic properties
- (vi) sealing fluids
- (vii) tension and compression
- (viii) conversion units
- (ix) basic pneumatics

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 19: Pneumatic Signal
Transmission Systems

UNIT 1: Transmitters

OPERATIONS

KNOWLEDGE

3. Servicing transmitters

- (a) Interpretation of drawings and specifications to determine:
 - (i) location
 - (ii) machinery details
 - (iii) fluid pressure, temperature and type
 - (iv) function
- (b) Interpretation of manufacturer's literature to determine:
 - (i) recommended maintenance procedure
 - (ii) parts description and identification
 - (iii) principle of operation
 - (iv) methods of replacing parts
 - (v) input - output values
 - (vi) overrange values
 - (vii) recommended ambient conditions
- (c) Importance of checking condition and regulation of air supply
- (d) Methods of repairing or replacing instrument air supply regulators and filters
- (e) Methods of bleeding air out of liquid filled sensing lines
- (f) Procedures for "blowing down" sensing lines
- (g) Type and method of removing and replacing sealing fluids
- (h) Importance and methods of checking transmitter zero adjustment
- (i) Procedures for cleaning baffle and nozzle
- (j) Methods of replacing dampening fluids
- (k) Methods of detecting and repairing:
 - (i) transmission leaks
 - (ii) low or high air supply
 - (iii) plugged or dirty sensing lines
 - (iv) loose or broken linkages, bearings, etc.
 - (v) leaking, diaphragms, gaskets or connections
 - (vi) plugged or dirty nozzles, baffles, pilot valves, relays

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 19: Pneumatic Signal
Transmission Systems

UNIT 1: Transmitters

OPERATIONS

KNOWLEDGE

3. Servicing transmitters (cont'd)
- (1) Methods of repairing or replacing:
 - (i) small isolating or by-pass valves
 - (ii) air bleed valves
 - (iii) metal or plastic tubing and connectors
 - (iv) gaskets or valve packing
 - (v) baffles and nozzles
 - (vi) bellows, diaphragms, bourdon, springs needle valves
 - (vii) pilot relays or relay stems
 - (viii) booster relays
 - (ix) plain, anti-friction, or thrust bearings
 - (x) torsion rods and shafts
 - (xi) pivot bearings or flexure strips
 - (xii) small machine screws and locking devices
 - (xiii) others
 - (m) Methods of removing, cleaning and replacing mercury sealing fluid
 - (n) Procedures for repairing or replacing floats or bells
 - (o) Type and procedure for repairing or replacing indicator pointers and dials
 - (p) Methods of repairing, replacing and calibrating small pressure gauges
 - (q) Effects of corrosive atmospheres and protective measures
 - (r) Methods of isolating transmitters from process lines and procedures for turning on to process lines
 - (s) Effects of excessive vibration
 - (t) Type, use and application of lubricants
 - (u) Mathematics: to calculate errors, pressure conversions, mechanical advantage and settings:
 - (i) linear measurement
 - (ii) ratio and proportion
 - (iii) powers and roots
 - (iv) percentages
 - (v) circles, arcs, angles
 - (vi) graphs, simple equations

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 19: Pneumatic Signal
Transmission Systems

UNIT 1: Transmitters

OPERATIONS

KNOWLEDGE

3. Servicing transmitters (cont'd) (v) Science:

- (i) levers and mechanical advantage
- (ii) spring rate
- (iii) torque, torsion, tension and compression
- (iv) sealing fluids
- (v) magnetic properties
- (vi) basic pneumatics
- (vii) lubricants and their uses

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 19: Pneumatic Signal
Transmission Systems

UNIT 2: Receivers

OPERATIONS

KNOWLEDGE

1. Installing and calibrating
receivers

- (a) Interpretation of drawings and specifications to determine:
 - (i) location
 - (ii) function
 - (iii) mounting details
 - (iv) service requirements
- (b) Interpretation of manufacturer's literature to determine:
 - (i) type
 - (ii) principle of operation
 - (iii) recommendations for mounting and connecting
 - (iv) adjustments
 - (v) pressure range
 - (vi) overrange limits
- (c) Classes of receivers:
 - (i) indicating
 - (ii) recording
- (d) Type of receiver mountings:
 - (i) field
 - (ii) panel
- (e) Type, principle and method of installing receiving elements:
 - (i) bourdon springs
 - (ii) bellow
 - (iii) diaphragms
 - (iv) pneumatic servo-motors
- (f) Type, use and method of installing readout systems:
 - (i) dials, linear and square root
 - (ii) flat or curved scales, linear square root or percentage
 - (iii) recorder chart mechanisms
 - (iv) others
- (g) Procedures for installing:
 - (i) indicators or pen arms
 - (ii) pointer or pen take-off arms and linkages
 - (iii) inking systems
- (h) Methods of calibrating receiving systems:
 - (i) indicating units
 - (ii) circular or strip chart recorders

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 19: Pneumatic Signal
Transmission Systems

UNIT 2: Receivers

OPERATIONS	KNOWLEDGE
<hr/>	
1. Installing and calibrating receivers (cont'd)	(i) Care and use of pneumatic test equipment: (i) shop (ii) in-plant (iii) primary and secondary standards (j) Methods of adjusting receiving systems for: (i) zero (ii) span (iii) linearity (k) Importance of adjusting pen or key pen of recorders to track on correct time arc (l) Methods of adjusting overrange stops on receiving elements (m) Procedures for installing and adjusting pulsation dampeners (n) Mathematics: for layout and to calcu- late linkage and pressure relations, errors: (i) linear measurement (ii) ratio and proportion (iii) percentages (iv) powers and roots (v) circles, arcs, angles (vi) graphs, simple equations (o) Science: (i) levers, mechanical advantage, linkages (ii) spring rate (iii) tension and compression (iv) basic pneumatics

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 19: Pneumatic Signal
Transmission Systems

UNIT 2: Receivers

OPERATIONS

KNOWLEDGE

2. Servicing receivers

- (a) Interpretation of drawings and specifications to determine:
 - (i) location
 - (ii) function
 - (iii) service requirements
- (b) Interpretation of manufacturer's literature to determine:
 - (i) type and principles of operation
 - (ii) recommended maintenance procedures
 - (iii) parts identification
 - (iv) input valves
- (c) Methods of inspecting for linkage wear and overrange of receiving elements
- (d) Procedures for cleaning pen systems
- (e) Methods of adjusting time and tracking of pens
- (f) Type, use and purpose of dead-end test equipment
- (g) Methods of replacing receiving elements
- (h) Importance of making zero and range checks on indicators or recorders
- (i) Effects of linkage misalignment on accuracy
- (j) Type, use and method of replacing plastic or metal tube connectors to instrument bulkheads
- (k) Use of soap and water to detect air leaks
- (l) Type, use and method of applying protective coatings
- (m) Importance of proper identification of measuring systems
- (n) Type, size and use of small metal fasteners and locking devices
- (o) Mathematics:
 - (i) linear measurement
 - (ii) circle, arcs and angles
 - (iii) powers and roots
 - (iv) percentages
 - (v) graphs, simple equations
- (p) Science:
 - (i) levers, linkages and mechanical advantage
 - (ii) spring rate
 - (iii) tension and compression
 - (iv) organic solvents
 - (v) basic pneumatics

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 20: Electrical Signal Transmission and Telemetry

TABLE OF CONTENTS

UNIT 1: Transmitters	Page 445
2: Receivers	453

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

, MEASUREMENT .

BLOCK 20: Electrical Signal Trans- UNIT 1: Transmitters
mission and Telemetering

OPERATIONS

KNOWLEDGE

1. Installing transmitters

- (a) Interpretation of drawings to determine:
 - (i) purpose
 - (ii) location
 - (iii) mounting details
 - (iv) primary element connection details
 - (v) services required
 - (vi) details of connections to transmission lines
 - (vii) type, length and route of transmission line
- (b) Interpretation of manufacturer's literature to determine:
 - (i) details of measurement components and circuit
 - (ii) details of signal components and circuit
 - (iii) measurement and signal values
 - (iv) recommended installation procedure
 - (v) signal and service connection details
- (c) Type, function, use and method of generating electrical signals such as:
 - (i) current adjusting
 - (ii) voltage adjusting
 - (iii) position adjusting
 - (iv) pulse, various types
 - (v) coded signal
 - (vi) frequency modulation
 - (vii) digital
 - (viii) others
- (d) Methods of adapting electric signal generating equipment to standard components for measuring process variables
- (e) Type, use and detail of direct converting devices or transducers for generating electric signals from process variables
- (f) Type, purpose and method of providing electrical power at transmitter:
 - (i) separate source at transmitter
 - (ii) source common to receiver and transmitter
 - (iii) regulated and unregulated sources
- (g) Type, use and construction of power regulating devices
- (h) Type, use and construction of digital converters and coding devices

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 20: Electrical Signal Trans- UNIT 1: Transmitters
mission and Telemetering

OPERATIONS	KNOWLEDGE
1. Installing transmitters (cont'd)	<ul style="list-style-type: none">(i) Use, principles and construction details for converting multiple transmitter signals to single channel transmission(j) Type, use, principle and detail of devices used to select signal transmission from a group of transmitters on demand from a single call channel(k) Type, use, principle and detail of devices used to transmit signals from measuring transmitters on demand from dial telephones(l) Methods of compensating for ambient temperature variations(m) Methods of making electrical connections between transmitting components(n) Procedures for mounting electrical components(o) Methods of protecting electrical transmitting components against corrosive or hazardous atmosphere(p) Type, use and method of connecting transmission wires:<ul style="list-style-type: none">(i) open wire(ii) shielded(iii) two and three wire runs(iv) telephone wires(v) power lines(q) Use of radio and microwave equipment for signal transmission(r) Mathematics:<ul style="list-style-type: none">(i) linear and angular measurement for layout(ii) logarithms, algebra, graphs, and trigonometry to understand electrical theory(s) Science:<ul style="list-style-type: none">(i) basic measurement theory(ii) basic electrical and electronic theory(iii) elementary theory of radio and telephone transmission(iv) basic theory of analog and digital signal systems(v) levers, linkages, gears

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 20: Electrical Signal Trans- UNIT 1: Transmitters
mission and Telemetry

OPERATIONS

KNOWLEDGE

2. Calibrating transmitters

- (a) Interpretation of manufacturer's literature to determine:
 - (i) measurement system details
 - (ii) signal generating system details
 - (iii) recommended calibrating techniques
 - (iv) specific values of input and output signals of each component
- (b) Use of primary and secondary standards
- (c) Type, use and detail of calibrating and test equipment:
 - (i) hydraulic
 - (ii) pneumatic
 - (iii) electrical
- (d) Methods of calibrating standard measurement systems for various process variables such as:
 - (i) pressure
 - (ii) temperature
 - (iii) flow
 - (iv) level
 - (v) others
- (e) Techniques of adjusting electromechanical linkages and switches to produce outputs proportional to values generated by standard measuring components
- (f) Importance of zero, range, linearity and sensitivity
- (g) Special techniques for checking and adjusting signal values from transducers which are part of or directly connected to primary elements
- (h) Use of special aids or techniques to determine or reproduce the shape, magnitude, frequency and duration of electrical wave forms such as:
 - (i) timing devices
 - (ii) oscilloscopes
 - (iii) signal generators
 - (iv) others
- (i) Importance and methods of adjusting rate of response
- (j) Effects of sensitivity adjustment on signal values

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 20: Electrical Signal Trans- UNIT 1: Transmitters
mission and Telemetering

OPERATIONS

KNOWLEDGE

2. Calibrating transmitters
(cont'd)

- (k) Importance of individual and overall checking of input-output values when calibrating multiple component transmitters
- (l) Mathematics:
 - (i) linear and angular measurements to determine linkage adjustments
 - (ii) logarithms, algebra, trigonometry, to interpret signals and understand theory
 - (iii) powers, roots, percent, graphs to plot and interpret results
- (m) Science:
 - (i) basic measurement, electrical and electronic theory
 - (ii) mechanical levers, linkages and gear systems

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 20: Electrical Signal Trans- UNIT 1: Transmitters
mission and Telemetering

OPERATIONS

KNOWLEDGE

3. Servicing transmitters

- (a) Interpretation of manufacturer's literature to determine:
 - (i) type and details of components
 - (ii) assembly and disassembly of components
 - (iii) wiring schematics
 - (iv) check points and values
 - (v) recommended maintenance and trouble shooting procedures
 - (vi) parts description and identification
 - (vii) signal and power connection details
- (b) Methods of repairing or replacing mechanical components, such as:
 - (i) shafts, bearings, pivots, springs
 - (ii) levers, gears, cams
 - (iii) connection and mounting blocks
 - (iv) hinges and seals
 - (v) indicators and dials
 - (vi) counters
- (c) Methods of repairing or replacing electrical components, such as:
 - (i) terminal connections
 - (ii) internal wiring
 - (iii) switching devices
 - (iv) relays and tubes
 - (v) power packs, amplifiers, transformers
 - (vi) others
- (d) Importance of lubricating cams and gears
- (e) Use of special aids or techniques to determine or reproduce the shape, magnitude, frequency and duration of electrical wave forms such as:
 - (i) timing devices
 - (ii) oscilloscopes
 - (iii) signal generators
 - (iv) others
- (f) Methods of using and troubleshooting with:
 - (i) ohmmeters, voltmeters, ammeters
 - (ii) wattmeter
 - (iii) condenser and resistance decade boxes
 - (iv) bridge test instruments AC & DC
 - (v) meggar

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 20: Electrical Signal Trans- UNIT 1: Transmitters
mission and Telemetering

OPERATIONS	KNOWLEDGE
<hr/>	
3. Servicing transmitters (cont'd)	<ul style="list-style-type: none">(g) Importance of segregating major electrical blocks to determine faults when trouble-shooting(h) Methods of determining electrical values after each major component(i) Procedures for replacing and testing elements of major electrical components such as:<ul style="list-style-type: none">(i) resistors(ii) condensers(iii) transformers(iv) transistors(v) rectifiers(vi) tubes(vii) others(j) Techniques of soldering(k) Methods of cleaning electrical contacts(l) Effects and causes of leakage paths, open circuits and shorts(m) Methods of repairing or replacing component parts of small electrical motors(n) Causes of high noise to signal ratios in transmission systems(o) Type, use and method of checking transmission lines(p) Type, size, use and method of insulating and shielding electrical wires(q) Mathematics:<ul style="list-style-type: none">(i) linear and angular measurements to determine size of, and adjust linkage and gear systems(ii) logarithms, algebra, trigonometry, to interpret test readings(r) Science:<ul style="list-style-type: none">(i) mechanical lever, linkage and gear systems(ii) basic measurement, electrical and electronic theory(iii) conductors and insulators(iv) simple generators AC and DC(v) electrical circuits

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 20: Electrical Signal Trans- UNIT 2: Receivers
mission and Telemetering

OPERATIONS

KNOWLEDGE

1. Installing receivers

- (a) Interpretation of drawings to determine:
 - (i) purpose
 - (ii) location
 - (iii) mounting details
 - (iv) service requirements and details
- (b) Interpretation of manufacturer's literature to determine:
 - (i) type and principle of operation
 - (ii) mounting recommendations
 - (iii) signal and power connection details
- (c) Type, use and general function of receiver systems:
 - (i) position
 - (ii) direct current or voltage
 - (iii) impulse (frequency, time duration amplitude, matching and others)
 - (iv) digital
- (d) Type, use, function and principle of major receivers:
 - (i) synchromotors
 - (ii) deflection indicators
 - (iii) self-balancing bridge instruments
 - (iv) other bridge instruments
 - (v) electro-mechanical devices
 - (vi) digital counters
 - (vii) logging devices
- (e) Type, use, function and construction details of major receiver components such as:
 - (i) recording or printing pen mechanisms
 - (ii) small electric motors
 - (iii) electro-mechanical relays, cams, clutches
 - (iv) electronic switches, inductance, coils, and oscillators
 - (v) power supplies, amplifiers, transformers and rectifiers
 - (vi) standardising circuits
 - (vii) counters

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 20: Electrical Signal Trans- UNIT 2: Receivers
mission and Telemetering

OPERATIONS	KNOWLEDGE
1. Installing receivers (cont'd)	(f) Methods and details of components used to: <ul style="list-style-type: none">(i) subtract or add signals(ii) separate and direct to individual receivers, multiple signals(iii) telemeter on single circuits or channels(iv) select by dial telephone or other methods a single measurement from a multi-signal transmission
	(g) Type, use and function of intergrating circuits and/or mechanisms
	(h) Procedures for installing panels
	(i) Methods of mounting receivers in panels
	(j) Methods of connecting signal or power wiring to receiver components
	(k) Type, size, insulation, shielding and use of electrical wiring
	(l) Type, size and method of making terminal connections of electrical wiring
	(m) Procedures for preventing explosions in hazardous atmospheres
	(n) Procedures for testing receiving components after installation
	(o) Type and use of electrical test equipment
	(p) Mathematics: <ul style="list-style-type: none">(i) linear and angular measurements for layout(ii) logarithms, algebra, trigonometry to understand theory
	(q) Science: <ul style="list-style-type: none">(i) mechanical levers, linkages and gear trains(ii) basic measurement, electrical and electron theory

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 20: Electrical Signal Trans- UNIT 2: Receivers
mission and Telemetering

OPERATIONS

KNOWLEDGE

2. Calibrating receivers

- (a) Interpretation of manufacturer's literature to determine:
 - (i) type and principle of operation
 - (ii) recommended procedures for calibrating mechanical electromechanical and electrical components
 - (iii) test valves for minimum, maximum and range
- (b) Methods of checking receiver by providing test signals at:
 - (i) receiver
 - (ii) transmitter
- (c) Methods of checking transmitter inputs at receivers
- (d) Type and use of calibrating and test equipment:
 - (i) potentiometers
 - (ii) decade boxes of resistance, capacitance, etc.
 - (iii) signal generators
 - (iv) oscilloscopes
- (e) Procedures for calibrating receivers for zero, range and linearity
- (f) Methods of checking and adjusting counting or integrating systems
- (g) Importance of repeatability
- (h) Effects of leakage paths, shorts and open circuits
- (i) Methods of adjusting sensitivity and effects on calibration
- (j) Procedures for adjusting timing or time cycling devices
- (k) Type, function and method of adjusting electronic circuits or mechanical devices used for dampening
- (l) Methods used to check and calibrate range suppression components
- (m) Procedures for calibrating mechanical and electro-mechanical integrators
- (n) Importance of checking transmission system and receiver resistance or impedance

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 20: Electrical Signal Trans- UNIT 2: Receivers
mission and Telemetering

OPERATIONS	KNOWLEDGE
<hr/>	
2. Calibrating receivers (cont'd)	(o) Mathematics: (i) linear and angular dimensions for checking sizes, motion and adjust- ment of mechanical devices (ii) logarithms, algebra and trigonome- try to interpret readings of test instruments (p) Science: (i) mechanical levers, linkages, gear trains (ii) basic measurement, electrical and electronic theory (iii) elementary motor theory

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 20: Electrical Signal Trans- UNIT 2: Receivers
mission and Telemetering

OPERATIONS

KNOWLEDGE

3. Servicing receivers

- (a) Interpretation of manufacturer's literature to determine:
 - (i) type, detail and principle of operation
 - (ii) assembly and disassembly of components
 - (iii) wiring schematics
 - (iv) electrical check points and valves
 - (v) recommended maintenance and trouble shooting procedures
 - (vi) signal and power connection details
 - (vii) parts description and identification
- (b) Methods of repairing or replacing mechanical components:
 - (i) recording or printing mechanisms
 - (ii) levers, cams, gears and clutches
 - (iii) integrators
 - (iv) others
- (c) Methods of repairing or replacing electrical components:
 - (i) wiring and wiring connections
 - (ii) small motors
 - (iii) power packs, amplifiers, conversion devices
 - (iv) switching devices, relays, tubes
 - (v) measuring circuits
- (d) Procedures for testing and isolating major components when trouble-shooting
- (e) Type, use, and function of test instruments:
 - (i) VTVM
 - (ii) timing devices
 - (iii) ohmmeter, ammeter, voltmeter
 - (iv) signal generators
 - (v) oscilloscopes
 - (vi) AC and DC bridge instruments
 - (vii) others
- (f) Use and principles of tube testers
- (g) Importance of testing or checking for:
 - (i) shorts, open circuits and leakage paths
 - (ii) insulation or shielding

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 20: Electrical Signal Trans- UNIT 2: Receivers
mission and Telemetering

OPERATIONS	KNOWLEDGE
3. Servicing receivers (cont'd)	(h) Limits of transmission distance and effect on receivers (i) Type, use and frequency of applying lubricants (j) Effects of corrosive atmospheres (k) Procedures for cleaning or burnishing electrical contacts (l) Methods of protecting against explosions in hazardous atmospheres (m) Methods of isolating receivers or receiver components from vibration (n) Effects of electrical interference and high noise to signal ratio (o) Techniques of soldering and repairing wires and making connections (p) Mathematics: (i) linear and angular measurements to determine size, layout and adjustments (ii) logarithms, algebra, trigonometry, to understand theory to interpret test equipment (q) Science: (i) mechanical levers, linkages, and gear trains (ii) basic measurement, electrical and electronic theory (iii) lubricants and their uses (iv) corrosive atmospheres

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 21: General Alarm and Signal Devices

TABLE OF CONTENTS

UNIT 1: Sensing Devices	Page 458
2: Receiving Devices	461

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 21: General Alarm and
Signal Devices

UNIT 1: Sensing Devices

OPERATIONS

KNOWLEDGE

1. Installing sensing devices

- (a) Interpretation of drawings to determine:
 - (i) use and purpose
 - (ii) location
 - (iii) connection details
 - (iv) wiring details
 - (v) mounting details
- (b) Interpretation of manufacturer's literature to determine:
 - (i) type and model
 - (ii) range limits
 - (iii) overrange protection
 - (iv) normal condition of contacts and number of contacts
 - (v) wiring connections
- (c) Type, use and construction details of elements used to produce mechanical motion from process variables:
 - (i) bourdon spring
 - (ii) bellows
 - (iii) diaphragms
 - (iv) piston
 - (v) others
- (d) Type, use, construction details, and rating of switches used with mechanical motion elements:
 - (i) spring leaf
 - (ii) mercury
 - (iii) others
- (e) Type, use and construction details of electrical sensors:
 - (i) resistance
 - (ii) inductance
 - (iii) conductance
 - (iv) capacitance
 - (v) photo-electric
 - (vi) sonic
 - (vii) radio-active
- (f) Methods of mounting components
- (g) Methods of connecting electrical wiring
- (h) Procedures for connecting to process
- (i) Type and use of explosion proof housings
- (j) Mathematics -
 - linear and angular measurement for layout

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 21: General Alarm and
Signal Devices

UNIT 1: Sensing Devices

OPERATIONS

KNOWLEDGE

1. Installing sensing devices
(cont'd)

(k) Science:

- (i) basic electrical theory
- (ii) mechanical levers, linkages
- (iii) elementary theory of radio-active
emissions

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 21: General Alarm and
Signal Devices

UNIT 1: Sensing Devices

OPERATIONS

KNOWLEDGE

2. Calibrating and servicing

- (a) Interpretation of manufacturer's literature to determine:
 - (i) adjustment details
 - (ii) recommended maintenance procedures
 - (iii) rating
 - (iv) parts identification
- (b) Methods of adjusting settings:
 - (i) set point
 - (ii) differential
 - (iii) upper and lower limits
- (c) Methods of adjusting switch actuators and gap
- (d) Procedures for adjusting light sources
- (e) Use of test equipment
- (f) Methods of replacing linkages, switches, tubes, etc.
- (g) Use of test pieces for adjusting radio-active sources and detectors
- (h) Importance and use of shielding and shutters on radio-active sources
- (i) Use and methods of adjusting small switches and their component parts in standard instruments:
 - (i) cams
 - (ii) linkages
 - (iii) springs
- (j) Importance of testing operation after calibration or servicing
- (k) Mathematics:
 - (i) linear and angular measurement for calibration
 - (ii) ratio and proportion for calibrating linkages
- (l) Science:
 - (i) springs, linkages, levers
 - (ii) basic electricity
 - (iii) basic electronics including photo-tubes
 - (iv) theory of sound or pressure waves
 - (v) elementary theory of emission from radio-active sources

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 21: General Alarm and
Signal Devices

UNIT 2: Receiving Devices

OPERATIONS

KNOWLEDGE

1. Installing receiving devices
- (a) Interpretation of drawings to determine:
 - (i) purpose
 - (ii) location of components
 - (iii) details of panels
 - (iv) mounting details
 - (v) service requirements
 - (vi) wiring schematics and details
 - (b) Interpretation of manufacturer's literature to determine:
 - (i) type and function
 - (ii) methods of making wiring connections
 - (iii) recommended installation procedure
 - (c) Type, use and function of receiving units:
 - (i) audible
 - (ii) simple display, coloured lights and back lighted translucent nameplates
 - (iii) complex display, scanning plus lights, scanning plus printout, recording
 - (iv) combinations
 - (d) Methods and components used to convert miscellaneous signals values to uniform or standard values
 - (e) Use of solid state components
 - (f) Type, use and function of relays to provide correct action, single display from multiple sensing devices, event sequence, or contacts for audible alarms
 - (g) Type and function of audible alarms and methods of cancelling
 - (h) Type and use of flashing lights or colour to determine alarm condition
 - (i) Use of electric typewriter and teletype mechanisms for print-out of alarm conditions
 - (j) Importance of proper identification of alarm points
 - (k) Methods of mounting panels and components in panels

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 21: General Alarm and
Signal Devices

UNIT 2: Receiving Devices

OPERATIONS

KNOWLEDGE

1. Installing receiving devices

- (l) Methods of installing, connecting and identifying panel and external wiring
- (m) Procedures for testing complete circuit
- (n) Use of electric circuit test instruments
- (o) Importance of correct range and action of circuit and its components
- (p) Mathematics:
 - (i) linear dimensions for layout
 - (ii) powers, roots, logarithms, trigonometry, and simple equations to understand theory
- (q) Science:
 - (i) levers, linkages, cams, gears and springs
 - (ii) basic electricity, particularly switching and time delay circuits
 - (iii) display lights and tubes
 - (iv) basic electronics, particularly solid-state

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 21: General Alarm and
Signal Devices

UNIT 2: Receiving Devices

OPERATIONS

KNOWLEDGE

2. Calibrating and servicing
receiving devices

- (a) Interpretation of manufacturer's literature on components to determine:
 - (i) type and model
 - (ii) range, span and adjustment details
 - (iii) general assembly details
 - (iv) parts identification and substitution
 - (v) details of wiring and connections
- (b) Methods of adjusting signal conversion devices for range, maximum and minimum alarm points
- (c) Procedures for adjusting relay contacts
- (d) Methods of adjusting cam or linkage operated switches
- (e) Importance of checking actuation differential of electric contacts
- (f) Methods of setting alarm sequencing mechanisms
- (g) Use of electrical test instruments for checking circuits
- (h) Methods of checking, replacing or repairing electric relays
- (i) Procedures for checking and replacing tubes
- (j) Methods used to determine:
 - (i) leakage paths
 - (ii) high resistance
 - (iii) shorts
- (k) Procedures for making panel cutouts changing alarm identification plates or windows
- (l) Importance of identifying wiring and connections when servicing electrical networks
- (m) Type, use and method of replacing wiring and terminal connections
- (n) Procedures for checking and cleansing printed circuits
- (o) Type, use and method of replacing solid state components

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 21: General Alarm and
Signal Devices

UNIT 2: Receiving Devices

OPERATIONS	KNOWLEDGE
<hr/>	
2. Calibrating and servicing receiving devices (cont'd)	(p) Mathematics: (i) linear measurement for layout (ii) powers, roots, ratio and propor- tion, logarithms, simple equations to analyse networks and interpret readings (q) Science: (i) levers, linkages, gears and cams (ii) basic electricity and electronics (iii) simple network analysis

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE
 . MEASUREMENT .

BLOCK 22: Data Processing

TABLE OF CONTENTS

UNIT 1: Signal Input Devices	Page 466
2: Data and Alarm Scanning Systems	473
3: Conversion, Readout and Control Devices	477

. MEASUREMENT .

BLOCK 22: Data Processing

UNIT 1: Signal Input Devices

OPERATIONS

KNOWLEDGE

-
1. Installing signal input devices
- (a) Interpretation of drawings, specifications and manufacturer's instructions to determine:
 - (i) type and application
 - (ii) location and mounting
 - (iii) electrical circuitry, pipe and tube layout
 - (iv) electrical power and air supply requirements
 - (b) Importance of adherence to relevant codes and regulations
 - (c) Classification of signal input devices:
 - (i) direct or indirect analog
 - (ii) digital
 - (d) Type, purpose and function of signal input devices:
 - (i) primary measurement transducers
 - (ii) re-transmitting devices
 - (e) Methods of installing transducers and transmitters
 - (f) Component mounting considerations:
 - (i) accessibility
 - (ii) orientation
 - (iii) security
 - (g) Importance of avoiding extremes of temperature, vibration and corrosive environments
 - (h) Methods of installing, connecting and leak testing tubing, pipe and miscellaneous valves, regulators and filters, etc.
 - (i) Procedures for identifying, testing and connecting electrical conductors
 - (j) Purpose and function of conductor shielding
 - (k) Procedures for energizing electrical and pneumatic systems and establishing correct functioning of the installation
 - (l) Type, care, use and storage of electrical test meters, tools and equipment
 - (m) Mathematics -
 - linear measurement for layout

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 22: Data Processing

UNIT 1: Signal Input Devices

OPERATIONS

KNOWLEDGE

1. Installing signal input
devices (cont'd)

(n) Science:

- (i) corrosion
- (ii) scientific measurement
- (iii) heat measurement and transfer
- (iv) conductors and insulators
- (v) elementary circuitry
- (vi) amperage, voltage and resistance
- (vii) voltmeter, ammeter and ohmmeter
- (viii) measurement of power and energy
- (ix) air pressure and its measurement

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 22: Data Processing

UNIT 1: Signal Input Devices

OPERATIONS	KNOWLEDGE
<hr/>	
2. Calibrating signal input devices	<ul style="list-style-type: none">(a) Interpretation of drawings and manufacturer's manuals to determine:<ul style="list-style-type: none">(i) type and application(ii) recommended calibrating procedures(iii) measured range(iv) electrical connections and power requirements(v) air requirements and connections(vi) type and range of signal output(b) Type and purpose of calibration(c) Methods of calibrating to recognized standards, electrical, mechanical and pneumatic primary measuring devices, transducers and transmitters detecting miscellaneous physical and chemical changes(d) Type, purpose, care and use of:<ul style="list-style-type: none">(i) primary and secondary standard calibrating equipment(ii) electrical test equipment(e) Methods of connecting:<ul style="list-style-type: none">(i) electrical conductors(ii) pipe and tube(iii) mechanical drives(f) Techniques of applying calibrating equipment(g) Interpretation of applied and output signals(h) Methods of adjusting primary measurement devices, transducers and transmitters for:<ul style="list-style-type: none">(i) zero(ii) range(iii) linearity(i) Methods of synchronizing primary and retransmitting devices(j) Importance of:<ul style="list-style-type: none">(i) adequately securing all adjustment devices(ii) re-checking calibration(k) Type, care, use and storage of tools and equipment

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 22: Data Processing

UNIT 1: Signal Input Devices

OPERATIONS

KNOWLEDGE

2. Calibrating signal input
devices (cont'd)

(1) Mathematics:

- (i) percentage to establish calibrating check points
- (ii) ratio and proportion to calculate linkages and lever adjustments, etc.
- (iii) powers and roots for flow calibration calculations
- (iv) graphs for plotting and interpreting calibration curves
- (v) algebraic formulae and equations for calculation of signal input and output values

(m) Science:

- (i) scientific measurement
- (ii) density, specific gravity and hydrometers
- (iii) Pascal's principle
- (iv) heat measurement, temperature indicators and scales
- (v) pressure due to head
- (vi) air pressure and its measurement
- (vii) linkages and levers
- (viii) drives
- (ix) electricity
- (x) electronics

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 22: Data Processing

UNIT 1: Signal Input Devices

OPERATIONS	KNOWLEDGE
<hr/>	
3. Servicing signal input devices	<ul style="list-style-type: none">(a) Interpretation of drawings, specifications, manufacturer's manuals and relevant handbooks to determine:<ul style="list-style-type: none">(i) type, purpose and application(ii) operating principles(iii) component construction and materials(iv) electrical circuit values and detail(v) tube and pipe connections(vi) suggested servicing procedures(vii) recommended routine maintenance(viii) recommended spare parts(b) Type of signal input devices:<ul style="list-style-type: none">(i) thermocouples(ii) miscellaneous variable resistance devices(iii) voltage, current and differential transformers(iv) AC and DC generators(v) pulse transmitters(vi) piezoelectric devices(vii) pneumatic to electric transducers and connectors(viii) other(c) Procedures for determining and locating signal device malfunctions(d) Methods of removing, repairing, testing and replacing signal devices and signal device components:<ul style="list-style-type: none">(i) mechanical(ii) electrical(iii) pneumatic(e) Methods of identifying and connecting electrical conductors, tube and pipe(f) Procedures for cleaning and leak testing tube and pipe(g) Techniques of inspecting signal input devices for security, cleanliness and wear

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 22: Data Processing

UNIT 1: Signal Input Devices

OPERATIONS

KNOWLEDGE

3. Servicing signal input devices (cont'd)

- (h) Procedures for cleaning and lubricating miscellaneous mechanical and electrical signal device parts:
 - (i) pivots and bearings
 - (ii) mechanical drives
 - (iii) potentiometers and slidewires
 - (iv) brushes, wipers, contacts and commutators
 - (v) other
- (i) Type, care, use, storage and hazards of cleaning agents and lubricants
- (j) Methods of testing electrical conductors and circuit components for:
 - (i) insulation
 - (ii) continuity
 - (iii) resistance
 - (iv) capacity
- (k) Procedures for measuring miscellaneous circuit parameters:
 - (i) voltage
 - (ii) current
 - (iii) frequency
 - (iv) phase
 - (v) impedance
- (l) Type, care and use of electrical test meters:
 - (i) voltohmmeters
 - (ii) vacuum tube voltmeters
 - (iii) meggers
 - (iv) oscilloscopes
 - (v) portable potentiometers and galvanometers
 - (vi) portable resistive, capacitive and inductance bridges
- (m) Type, care, use and storage of tools and equipment
- (n) Mathematics -
 - algebraic formulae to calculate electrical values

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 22: Data Processing

UNIT 1: Signal Input Devices

OPERATIONS	KNOWLEDGE
<hr/>	
3. Servicing signal input devices (cont't)	(o) Science: <ul style="list-style-type: none">(i) scientific measurement(ii) air pressure and its measurement(iii) type of lubricants and their uses(iv) organic solvents(v) linkages and levers(vi) drives(vii) fits and clearances(viii) electricity(ix) electronics

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 22: Data Processing

UNIT 2: Data and Alarm
Scanning Systems

OPERATIONS

KNOWLEDGE

1. Servicing data and alarm
scanning systems

- (a) Interpretation of drawings, specifications and manufacturer's literature to determine:
 - (i) type, purpose and operating principles
 - (ii) system utility
 - (iii) major components, their function, construction and location
 - (iv) circuit layouts, function and power requirements
 - (v) adjustment, testing and maintenance facilities and recommendations
 - (vi) suggested trouble shooting procedures
 - (vii) recommended spare parts
- (b) Functions of the scanning system:
 - (i) sample, attenuate, convert and compensate analog input signals
 - (ii) provide alarm detection facilities
 - (iii) obey miscellaneous programming and sequential control commands
- (c) Type and purpose of scanning circuits:
 - (i) input signal manipulation
 - (ii) signal selection and point identification
 - (iii) data storage and memory
 - (iv) alarm comparator
 - (v) high and low deviation limits
 - (vi) set point hysteresis
 - (vii) self checking and safeguarding
 - (viii) other
- (d) Type, purpose and function of scanning system components:
 - (i) stepping switches
 - (ii) relays
 - (iii) diode matrices
 - (iv) circuit boards and modules
 - (v) capacitors and resistors
 - (vi) cold junction compensators
 - (vii) slidewire, helipots and potentiometers
 - (viii) magnetic drums
 - (ix) regulated power supplies
 - (x) amplifiers
 - (xi) others

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 22: Data Processing

UNIT 2: Data and Alarm
Scanning Systems

OPERATIONS	KNOWLEDGE
<hr/>	
1. Servicing data and alarm scanning systems (cont'd)	<ul style="list-style-type: none">(e) Techniques of recognizing symptoms of, and locating, scanning system malfunctions(f) Methods of testing, removing, repairing and replacing components(g) Procedures for achieving "safe" circuit conditions before servicing components(h) Considerations when servicing and adjusting stepping switches and relays<ul style="list-style-type: none">(i) number of positions, levels and bridging combinations(ii) effects of arc suppression networks(iii) importance of correct orientation of mercury contact relays(iv) methods of compensating for thermocouple effect of mercury wetted contacts(v) methods of checking ratchets, cams and detent springs for wear and correct functioning(vi) importance of correct alignment of wiper and bank assemblies, springs and stops(vii) methods of setting and checking contacts for correct clearance and travel(viii) techniques of adjusting for correct tension of wipers, brushes and leaf springs(ix) importance of avoiding kinks and sharp bends(x) effects of and methods of adjusting resistive, capacitive and thermal delay times of relay(xi) effects of noise and transients(i) Type, care and use of tools required for relay and stepping switch adjustments:<ul style="list-style-type: none">(i) spring bender(ii) armature bender(iii) thickness gauges(iv) gram gauges(j) Procedures for checking circuits and components for insulation, resistance, continuity and capacity

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 22: Data Processing

UNIT 2: Data and Alarm
Scanning Systems

OPERATIONS

KNOWLEDGE

- | | |
|---|--|
| 1. Servicing data and alarm scanning systems (cont'd) | (k) Techniques of conductor and circuit component identification using colour codes
(l) Significance of, and methods of testing diode and capacitor resistive characteristics
(m) Techniques of soft soldering
(n) Importance of avoiding overheating of printed circuit boards and circuit components
(o) Methods of measuring voltage, current, frequency, phase and impedance
(p) Methods of simulating miscellaneous circuit values and signals
(q) Procedures for setting and adjusting sliders, helipots and calibrated dial potentiometers
(r) Effects of network interaction caused by resistive adjustments, and procedures for avoiding
(s) Methods of cleaning mounting cabinets, components, slidewires and contacts using:
(i) dry air jets
(ii) vacuum cleaners
(iii) alcohol
(iv) burnishing tools
(t) Procedures in establishing lubrication service for stepping switches:
(i) lubricant type
(ii) method of applying
(iii) frequency of application
(u) Care and storage of organic solvents and lubricants
(v) Type, use and function of conductive and insulating pastes, and fungicidal varnishes
(w) Type, care, use and storage of tools and equipment |
|---|--|

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 22: Data Processing

UNIT 2: Data and Alarm
Scanning Systems

OPERATIONS	KNOWLEDGE
<hr/>	
1. Servicing data and alarm scanning systems (cont'd)	<ul style="list-style-type: none">(x) Type, care, use and storage of electrical test meters and equipment:<ul style="list-style-type: none">(i) V.O.M. and V.T.V.M.(ii) tube testers(iii) impedance bridges(iv) impedance simulators (decades)(v) oscilloscopes(vi) portable potentiometers(vii) meggers(viii) signal generators(y) Mathematics:<ul style="list-style-type: none">(i) algebraic formula for electrical measurement calculations(ii) graphs for interpretation of component performance(z) Science:<ul style="list-style-type: none">(i) systems, units and techniques of measurement(ii) type and viscosity ratings of lubricants(iii) organic solvents(iv) electrostatics(v) conductors and insulators(vi) distribution and concentration of charges(vii) theory of electron flow(viii) elementary circuitry(ix) amperage, voltage and resistance(x) Ohm's law(xi) typical series and parallel circuits(xii) voltage drop and its measurement(xiii) voltmeter, ammeter and ohmmeter(xiv) electromagnetism(xv) transformers(xvi) elementary electronics(xvii) cathode ray tubes(xviii) rectification(xix) semi conductors

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 22: Data Processing

UNIT 3: Conversion, Readout and
Control Devices

OPERATIONS

KNOWLEDGE

1. Servicing conversion, readout
and control devices

- (a) Interpretation of drawings, specifications and manufacturer's manuals to determine:
 - (i) type, purpose and operating principles
 - (ii) location and function
 - (iii) electrical circuitry and power requirements
 - (iv) routine maintenance and servicing
 - (v) testing procedures and facilities
 - (vi) recommended spare parts
- (b) Classifications of devices:
 - (i) analog measurement
 - (ii) digital measurement
 - (iii) conversion
 - (iv) manipulation and computation (analog and digital)
 - (v) alarm readout
 - (vi) control
- (c) Type, purpose and function of analog measuring devices:
 - (i) self balancing potentiometers and bridges
 - (ii) null balance detectors
 - (iii) other
- (d) Type, purpose and function of digital measuring devices:
 - (i) typewriters
 - (ii) magnetic tapes
 - (iii) paper punch tapes and cards
 - (iv) oscilloscopes
 - (v) digital indicator lights
 - (vi) computers
 - (vii) other
- (e) Type, purpose and function of conversion device -
 - analog to digital converters and digicoders
- (f) Type, purpose and function of analog and digital manipulation devices:
 - (i) code converters
 - (ii) addition and subtraction
 - (iii) multiplication and division
 - (iv) integration
 - (v) extrapolation
 - (vi) other

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 22: Data Processing

UNIT 3: Conversion, Readout and
Control Devices

OPERATIONS	KNOWLEDGE
<hr/>	
1. Servicing conversion, readout and control devices (cont'd)	<ul style="list-style-type: none">(g) Type, purpose and function of alarm devices:<ul style="list-style-type: none">(i) visual signal(ii) audible signal(iii) alarm logging (typewriters, etc.)(iv) other(h) Type, purpose and function of programming and control devices:<ul style="list-style-type: none">(i) pulse generators(ii) magnetic drums(iii) patch boards(iv) pin boards(v) miscellaneous switches(vi) other(i) Type, purpose and function of conversion, readout and control device components:<ul style="list-style-type: none">(i) relays and relay logic systems(ii) diodes and diode matrices(iii) tubes, transistors and thyratrons(iv) slidewires, helipots, and rehostats(v) stepping switches, commutators, etched discs, brushes and wipers(vi) capacitors and resistors (R.C. networks)(vii) magnetic drums(viii) amplifiers(ix) power supplies and dry cells(x) servomechanisms, motors and drives(xi) solenoids(xii) timers(xiii) etched circuit boards and circuit modules(xiv) other(j) Methods of removing, testing, repairing and replacing devices, components and component parts(k) Significance of built-in test facilities to provide circuit and component isolation and operating mode, to assist in location of system malfunction

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 22: Data Processing

UNIT 3: Conversion, Readout and Control Devices

OPERATIONS

KNOWLEDGE

1. Servicing conversion, readout and control devices (cont'd)

- (1) Techniques of locating malfunctions where multiplexing of devices is employed
- (m) Procedures for localizing sources of trouble using circuit drawings and deductive analysis
- (n) Methods of testing electrical component and circuits for:
 - (i) insulation
 - (ii) continuity
 - (iii) resistance
 - (iv) capacity
- (o) Procedures for checking miscellaneous circuit parameters:
 - (i) potential
 - (ii) current
 - (iii) frequency
 - (iv) phase
- (p) Importance of achieving suitable circuit conditions prior to testing or servicing
- (q) Procedures for calibrating analog measuring devices
- (r) Methods of synchronizing analog measuring devices with A.D.C.'s
- (s) Methods of checking A.D.C.'s and manipulation devices using known code combinations
- (t) Procedures for inspecting mechanical parts of servomechanisms, A.D.C.'s stepping switches and digital measuring devices for correct function and wear:
 - (i) pivots and bearings
 - (ii) gear and pulley drives
 - (iii) clutches, cams, ratchets and pawls
 - (iv) linkages and levers
- (u) Methods and care in cleaning:
 - (i) precious metallated electrical contact surfaces
 - (ii) slidewires
 - (iii) pivots and bearings
- (v) Methods of lubricating mechanical contact and bearing surfaces

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. MEASUREMENT .

BLOCK 22: Data Processing

UNIT 3: Conversion, Readout and
Control Devices

KNOWLEDGE	OPERATIONS
<hr/>	
1. Servicing conversion, readout and control devices (cont'd)	<ul style="list-style-type: none">(w) Type, care, use, storage and hazard of:<ul style="list-style-type: none">(i) organic solvents(ii) air jets and guns(iii) lubricants(x) Type, care, use and storage of electrical test meters and equipment:<ul style="list-style-type: none">(i) V.O.M.'s and V.T.V.M.'s(ii) meggers(iii) tube testers(iv) oscilloscopes(v) impedance bridges(vi) impedance simulators(vii) portable potentiometers(y) Type, care, use and storage of tools and equipment(z) Mathematics<ul style="list-style-type: none">(i) graphs, for interpretation of electronic component performance characteristics and analog measuring devices calibrating signal(ii) algebraic formulae and equations for calculation of miscellaneous electrical values(aa) Science:<ul style="list-style-type: none">(i) systems, units and techniques of measurement(ii) air pressure(iii) lubricants, their viscosity ratings and uses(iv) metals for bearings(v) organic solvents(vi) electricity(vii) electronics(viii) nature of friction(ix) linkages and levers(x) ratchets and cams(xi) gear drives(xii) fits and clearances

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. CONTROL .

BLOCK 23: Self-Operated Controllers

TABLE OF CONTENTS

UNIT 1: Pressure Regulators	Page 482
2: Temperature Regulators	485
3: Level Controllers	487

. CONTROL .

BLOCK 23: Self-Operated
Controllers

UNIT 1: Pressure Regulators

OPERATIONS	KNOWLEDGE
1. Installing pressure regulators	<ul style="list-style-type: none"> (a) Interpretation of drawings to determine: <ul style="list-style-type: none"> (i) purpose (ii) service conditions (iii) location and method of mounting (b) Interpretation of manufacturer's instruction manuals to determine installation procedures (c) Type, characteristic and method of connecting pressure regulators: <ul style="list-style-type: none"> (i) direct loaded (ii) pilot loaded (iii) lever and weight operated (d) Type and characteristic of valve bodies: <ul style="list-style-type: none"> (i) globe pattern (ii) angle pattern (e) Materials of construction of valve body and pressure and temperature ratings (f) Type of end connections and methods of connection: <ul style="list-style-type: none"> (i) threaded (ii) flanged (g) Type and characteristic of gasket materials and methods of cutting and fitting (h) Methods of handling heavy regulators, use of hoists and chain blocks (i) Methods of cutting, bending and fitting piping and tubing (j) Procedure for checking for correct operation (k) Mathematics - <ul style="list-style-type: none"> linear and angular measurements for fitting, piping and gaskets (l) Science: <ul style="list-style-type: none"> (i) fluid flow in pipes (ii) gas laws

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. CONTROL .

BLOCK 23: Self-Operated
Controllers

UNIT 1: Pressure Regulators

OPERATIONS

KNOWLEDGE

2. Repairing and calibrating
pressure regulators

- (a) Interpretation of manufacturer's instruction manuals to determine repair and calibration procedures
- (b) Pressure and temperature ratings of valve bodies and end connections
- (c) Type and inner valve (trim):
 - (i) single port plug
 - (ii) double port plug
 - (iii) butterfly
- (d) Materials of construction of valve plugs and seats and their characteristics
- (e) Type and characteristic of diaphragm materials
- (f) Methods of transporting regulators and placing in position for dismantling
- (g) Procedures for dismantling regulators
- (h) Methods of inspecting, repairing or replacing valve components:
 - (i) seats and plugs
 - (ii) stem and gland packing
- (i) Procedures for repairing or replacing spring and diaphragm assembly, importance of correct spring rates
- (j) Methods of cleaning and repairing pilot relays
- (k) Procedures for re-assembling regulator
- (l) Methods of connecting regulator to test equipment and applying test pressures
- (m) Methods of adjusting pilot relay
- (n) Procedures for adjusting pilot relay
- (o) Methods of adjusting weight operated regulator
- (p) Methods of preventing "hunting"
- (q) Mathematics:
 - (i) area of a circle
 - (ii) calculation of pressures, moments, spring forces
- (r) Science:
 - (i) levers, linkages, moments
 - (ii) Pascal's principle
 - (iii) elasticity, spring rates

. CONTROL .

BLOCK 23: Self-Operated
Controllers

UNIT 2: Temperature Regulators

OPERATIONS	KNOWLEDGE
1. Calibrating self-acting temperature regulators	<ul style="list-style-type: none"> (a) Interpretation of manufacturer's instruction manuals to determine callibration procedures (b) Type and characteristic of temperature regulators: <ul style="list-style-type: none"> (i) direct acting (ii) pilot operated (c) Type and characteristic of filled system thermometers (d) Type, size and heat transfer characteristic of thermometer bulbs and wells (e) Temperature range of regulator and operating temperatures (f) Care and use of test equipment: <ul style="list-style-type: none"> (i) standard thermometers (ii) constant temperature baths (g) Methods of adjusting spring tension or pilot relay to obtain desired temperature setting (h) Mathematics - <ul style="list-style-type: none"> conversion of temperature scales (i) Science: <ul style="list-style-type: none"> (i) thermal expansion (ii) temperature scales (iii) heat transfer (iv) vapour pressure of liquids (v) gas laws

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. CONTROL .

BLOCK 23: Self-Operated
Controllers

UNIT 2: Temperature Regulators

OPERATIONS	KNOWLEDGE
<hr/>	
2. Installing self-operated temperature regulators	<ul style="list-style-type: none">(a) Interpretation of drawings to determine:<ul style="list-style-type: none">(i) type of regulator(ii) operation conditions(iii) location(iv) method of mounting(b) Type of valve and connections:<ul style="list-style-type: none">(i) threaded(ii) flanged(c) Methods of making threaded connections, and use of thread compounds(d) Type and characteristic of gasket materials and methods of cutting and fitting(e) Procedures for tightening nuts and use of torque wrenches where required(f) Type, size and material of construction of thermometer wells(g) Methods of installing thermometer wells in pipes and vessels(h) Type, size and material of construction of thermometer bulbs:<ul style="list-style-type: none">(i) plain(ii) union connection(i) Methods of installing bulbs in wells(j) Use of heat transfer media(k) Type and material of construction of capillary tubing and methods of protection and mounting(l) Methods of making pressure connections for pilot-operated regulators(m) Procedure for checking for correct operation(n) Mathematics -<ul style="list-style-type: none">linear and angular measurements for piping layout and fittinggaskets(o) Science:<ul style="list-style-type: none">(i) temperature scales(ii) heat transfer(iii) moments, torque

. CONTROL .

BLOCK 23: Self-Operated
Controllers

UNIT 2: Temperature Regulators

OPERATIONS	KNOWLEDGE
3. Servicing and repairing temperature regulators	<ul style="list-style-type: none"> (a) Interpretation of manufacturer's instruction manuals to determine service and repair procedures (b) Type, size and material of construction of valve bodies (c) Type and characteristic of inner valve construction: <ul style="list-style-type: none"> (i) single port (ii) double port (d) Type and characteristic of filled system thermometer (e) Service conditions (f) Procedures for removal of thermometer system and spring assembly (g) Procedures for removal of inner valve (h) Methods of inspection and repair of replacement of components: <ul style="list-style-type: none"> (i) seats and plugs (ii) stem and gland packing (i) Type of gland lubricant and methods of lubrication (j) Procedures for checking alignment of valve stem (k) Importance of avoiding hysteresis caused by friction on valve stem, and methods of checking (l) Methods of checking thermometer system for correct operation (m) Methods of refilling thermometer systems (n) Procedures for mounting bellows and spring assembly and methods of alignment (o) Methods of adjusting spring tension (p) Methods of adjusting valve stroke (q) Procedures for checking for correct operation (r) Science: <ul style="list-style-type: none"> (i) vapour pressure of liquids (ii) gas laws (iii) temperature scales (iv) physical properties of metals (v) Pascal's principle (vi) thermal expansion (vii) nature of friction (viii) modulus of elasticity, spring rates

. CONTROL .

BLOCK 23: Self-Operated
Controllers

UNIT 3: Level Controllers

OPERATIONS	KNOWLEDGE
1. Installing direct-acting float operated level controllers	<ul style="list-style-type: none"> (a) Interpretation of drawings to determine: <ul style="list-style-type: none"> (i) installation requirements (ii) service conditions (iii) location (b) Interpretation of manufacturer's instruction manuals to determine service conditions and location procedure (c) Method of mounting floats: <ul style="list-style-type: none"> (i) internal (ii) cage (d) Method of valve actuation: <ul style="list-style-type: none"> (i) direct (ii) internal pilot and piston (e) Type and characteristic of valve bodies: <ul style="list-style-type: none"> (i) globe (ii) angle (f) Type of end connections and methods of assembly: <ul style="list-style-type: none"> (i) threaded (ii) flanged (g) Type of tank stuffing boxes and methods of installation (h) Methods of mounting internal floats (i) Importance of adequate float size (j) Use of corrosion resistant materials (k) Methods of mounting valves in process lines (l) Methods of connecting floats and valves and adjusting counterweights (m) Procedures for adjusting valve stroke (n) Methods of mounting and supporting float cages (o) Importance of correct size of float cage equalizing connections (p) Methods of making equalizing connections (q) Importance of avoiding excessive friction in stuffing boxes (r) Type and characteristic of stuffing box gland packings and methods of tightening gland nuts (s) Type, application and temperature ratings of stuffing box lubricants

. CONTROL .

BLOCK 23: Self-Operated
Controllers

UNIT 3: Level Controllers

OPERATIONS	KNOWLEDGE
1. Installing direct-acting float operated level controllers (cont'd)	(t) Use of cooling fins on stuffing box for high temperature service (u) Methods of actuating alarm or control switches (v) Importance of adherence to relevant electrical codes and regulations (w) Procedures for checking for correct operation (x) Mathematics: volumes of spheres for calculation of buoyant forces and moments (y) Science: (i) density, specific gravity, buoyancy (ii) friction (iii) principle of turning moments (iv) units of mass and force (v) torque (vi) linkages, levers (vii) piston motion (viii) heat transfer (ix) elementary circuitry (x) lubricants and their uses

. CONTROL .

BLOCK 23: Self-Operated
Controllers

UNIT 3: Level Controllers

OPERATIONS

KNOWLEDGE

2. Repairing and servicing
direct-acting float operated
level controllers

- (a) Interpretation of manufacturer's instruction manuals to determine repair and service procedures
- (b) Procedures for removing float assembly from float cage
- (c) Methods of removing dirt or sediment from float cage and equalizing lines
- (d) Methods of inspecting, cleaning and repairing or replacing float
- (e) Procedures for checking linkages for friction, and methods of cleaning, lubricating and adjusting
- (f) Methods of checking valve stem packing for friction or leakage
- (g) Recognition of types of valve stem packing and methods of replacement
- (h) Methods of adjusting gland packing nuts, importance of avoiding excessive friction
- (i) Procedures for dismantling valve body
- (j) Methods of inspecting valve stems, plugs and seals for wear or corrosion
- (k) Methods of re-seating valves and replacement of worn or damaged parts
- (l) Procedures for assembling controller and checking alignment of moving parts
- (m) Methods of adjusting valve stem travel
- (n) Methods of repairing and adjusting alarm and control switches
- (o) Procedures for checking for correct operation
- (p) Mathematics -
volumes of spheres for calculation of buoyant forces and moments
- (q) Science:
 - (i) density, specific gravity, buoyancy
 - (ii) lubricants and their uses
 - (iii) linkages, levers, turning moments
 - (iv) elementary circuitry

BLOCK 24: Hydraulic Controllers

TABLE OF CONTENTS

UNIT 1: Hydraulic Control SystemsPage 491

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. CONTROL .

BLOCK 24: Hydraulic Controllers

UNIT 1: Hydraulic Control Systems

OPERATIONS

1. Installing, adjusting and servicing hydraulic control systems

KNOWLEDGE

- (a) Interpretation of drawings to determine:
 - (i) installation requirements
 - (ii) location of components and methods of mounting
 - (iii) service conditions
 - (iv) piping arrangement
- (b) Interpretation of manufacturer's instruction manuals and relevant handbooks to determine installation, adjustment and service procedures
- (c) Type and characteristics of hydraulic relays and fluids
- (d) Type and characteristics of hydraulic power sources:
 - (i) constant displacement pump
 - (ii) variable displacement pump
- (e) Type and characteristics of hydraulic power actuators:
 - (i) straight cylinder
 - (ii) crank cylinder
 - (iii) vane type cylinder
 - (iv) multiple piston
- (f) Type, use and method of installation of hydraulic accumulators
- (g) Methods of installing and connecting components to obtain:
 - (i) floating control
 - (ii) proportional control
 - (iii) proportional plus reset control
- (h) Procedure for making hydrostatic tests and checking for leaks
- (i) Procedures for checking system for correct operation
- (j) Mathematics:
 - (i) linear measurement and Pythagoras' theorem for piping layout
 - (ii) conversion of pressure units
- (k) Science:
 - (i) Pascal's principle
 - (ii) flow through pipes
 - (iii) impulse of liquid jets
 - (iv) piston motion
 - (v) static and sliding friction
 - (vi) basic control theory

. CONTROL .

BLOCK 24: Hydraulic Controllers

UNIT 1: Hydraulic Control Systems

OPERATIONS

KNOWLEDGE

2. Repairing and servicing hydraulic relays

- (a) Interpretation of manufacturer's instruction manuals to determine repair, service and procedures
- (b) Type and characteristic of hydraulic relays:
 - (i) four-way valve
 - (ii) double throttle
 - (iii) jet pipe
- (c) Type and characteristic of hydraulic fluids
- (d) Methods of dismantling and cleaning relays
- (e) Methods of checking sleeves, cylinders, pistons and spools for wear or corrosion
- (f) Procedures for repair, replacement, assembly and alignment of parts
- (g) Procedures for checking jet pipe for friction and methods of adjusting pivot
- (h) Type of piston rod packing and sealing, and methods of replacement
- (i) Methods of adjusting gland nuts
- (j) Procedure for making hydrostatic tests and checking for leaks
- (k) Procedure for checking for correct operation
- (l) Mathematics -
 - conversion of pressure units
- (m) Science:
 - (i) Pascal's principle
 - (ii) flow-through pipes
 - (iii) impulse of liquid jets
 - (iv) piston motion
 - (v) static and sliding friction

BLOCK 25: Pneumatic Controllers

TABLE OF CONTENTS

UNIT 1: Motion Balance Type Controllers	Page 494
2: Stack Type Force Balance Controllers	497
3: Beam Type Force Balance Controllers	500
4: Manual-Automatic Transfer Stations	503
5: Relays and Computers	505

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. CONTROL .

BLOCK 25: Pneumatic Controllers

UNIT 1: Motion Balance Type Controllers

OPERATIONS	KNOWLEDGE
<hr/>	
1. Installing motion balance type controllers	<ul style="list-style-type: none">(a) Interpretation of drawings and manufacturer's instruction manuals to determine:<ul style="list-style-type: none">(i) installation requirements(ii) service conditions(iii) method of mounting(iv) dimensions of panel cut-outs(v) piping arrangements(b) Type of supports for field mounted controllers, and methods of fabrication and installation(c) Type and characteristic of air drying filtering and regulating equipment, and methods of installation(d) Principles of operation of controller and modes of control(e) Methods of protection against corrosive atmospheres(f) Effects of vibration, and methods of protection(g) Methods of connecting controller to air supply system and other control components(h) Methods of checking for air leaks(i) Procedures for checking for correct operation(j) Mathematics -<ul style="list-style-type: none">linear measurement and Pythagoras' Theorem for mounting and piping layout(k) Science:<ul style="list-style-type: none">(i) properties of air(ii) gas laws(iii) atmospheric corrosion(iv) vibration(v) flow through pipes(vi) bolted, riveted and welded joint

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. CONTROL .

BLOCK 25: Pneumatic Controllers

UNIT 1: Motion Balance Type Controller

OPERATIONS	KNOWLEDGE
<hr/>	
2. Calibrating motion balance type controllers	<ul style="list-style-type: none">(a) Interpretation of manufacturer's instruction manuals to determine calibration procedures(b) Type and characteristics of error-detecting mechanisms:<ul style="list-style-type: none">(i) flapper and nozzle(ii) pilot valve(iii) free vane(c) Type and characteristics of pneumatic relays and amplifiers(d) Care, use and methods of connection of test equipment:<ul style="list-style-type: none">(i) pressure regulators(ii) manometer and pressure gauges(e) Methods of aligning flapper and nozzle(f) Procedures for checking and adjusting calibration of:<ul style="list-style-type: none">(i) proportional band(ii) reset time(iii) rate time(g) Methods of adjusting linkages and aligning set point index(h) Mathematics -<ul style="list-style-type: none">calculation of magnitude and rates of change of air pressure(i) Science:<ul style="list-style-type: none">(i) levers, linkages, gears(ii) gas laws(iii) flow through pipes(iv) basic control theory

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. CONTROL .

BLOCK 25: Pneumatic Controllers

UNIT 1: Motion Balance Type Controllers

OPERATIONS	KNOWLEDGE
<hr/>	
3. Repairing and servicing motion balance type controllers	<ul style="list-style-type: none">(a) Interpretation of manufacturer's instruction manuals to determine repair and service procedure(b) Service conditions(c) Importance of providing a clean, dry air supply(d) Procedure for checking and servicing the air supply system, methods of measuring dew point(e) Methods of checking external piping for leaks(f) Methods of disconnecting or removing control mechanism without disturbing the process(g) Methods of cleaning mechanisms(h) Importance of avoiding damage to linkage systems during cleaning(i) Methods of removing and cleaning air restrictions, nozzles and relays, use of solvents(j) Methods of aligning flapper and nozzle mechanisms(k) Procedures for determining causes of faulty operation, and methods of correction(l) Methods of replacing defective components and re-assembling of controllers(m) Methods of aligning set point index(n) Procedures for checking for correct operation(o) Science:<ul style="list-style-type: none">(i) vapour pressure(ii) force, moments(iii) levers, linkages, gears(iv) basic control theory

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. CONTROL .

BLOCK 25: Pneumatic Controllers

UNIT 2: Stack Type Force Balance
Controllers

OPERATIONS

KNOWLEDGE

1. Installing stack type
controllers

- (a) Interpretation of drawings and piping diagram to determine:
 - (i) installation requirements
 - (ii) location
 - (iii) method of mounting and connecting
- (b) Principle of operation of controller and modes of control
- (c) Methods of actuating set point index:
 - (i) remote
 - (ii) self-contained
- (d) Effects of vibration and methods of protection
- (e) Methods of protection against corrosive atmospheres
- (f) Methods of fitting and supporting metal and plastic tubing
- (g) Methods of connection to provide bumpless transfers from manual to automatic operation
- (h) Procedures for checking for leaks
- (i) Methods of putting controllers into operation and checking for faults
- (j) Mathematics -
 - linear measurement for layout
- (k) Science:
 - (i) gas laws
 - (ii) atmospheric corrosion
 - (iii) basic control theory
 - (iv) vibration

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. CONTROL .

BLOCK 25: Pneumatic Controllers

UNIT 2: Stack Type Force Balance
Controllers

OPERATIONS

KNOWLEDGE

2. Calibrating and aligning
stack type controllers

- (a) Interpretation of manufacturer's instruction manuals to determine calibration and alignment procedures
- (b) Care and use of test equipment and methods of assembling and connecting to controller
- (c) Methods of applying test pressures
- (d) Importance of checking for leaks
- (e) Procedure for making preliminary check of operation of controller over its full range
- (f) Methods of adjusting:
 - (i) deviation section
 - (ii) proportional band section
 - (iii) reset section
 - (iv) rate section
- (g) Importance of avoiding damage to flapper mechanism when adjusting deviation and rate nozzles
- (h) Methods of checking and adjusting reset and rate time values
- (i) Procedures for making final check of operation of controllers
- (j) Mathematics:
 - (i) percentages, for calculating controller settings
 - (ii) conversion of pressure units
 - (iii) calculation of rates of pressure change
- (k) Science:
 - (i) laws of equilibrium
 - (ii) gas laws
 - (iii) flow of gases through pipes, orifice, nozzles
 - (iv) basic control theory

. CONTROL .

BLOCK 25: Pneumatic Controllers

UNIT 2: Stack Type Force Balance
Controllers

3. Repairing and servicing
stack type controllers

- (a) Interpretation of manufacturer's instruction manuals to determine repair and service procedures
- (b) Importance of providing a clean, dry air supply
- (c) Methods of measuring dewpoint of air supply
- (d) Procedures for removal and replacement of air drying media and filter elements
- (e) Methods of blowing down air lines
- (f) Methods of checking external piping for leaks
- (g) Methods of removal, cleaning and replacement of fixed restrictions and needle valves
- (h) Type and use of solvents
- (i) Importance of keeping exhaust ports open
- (j) Methods of inspection of valves and valve seats for wear and methods of replacement
- (k) Procedures for aligning exhaust seat, ring and diaphragm
- (l) Methods of lubricating "O" rings
- (m) Procedures for diagnosing causes of faulty operation and methods of correction
- (n) Procedure for making final check of operation over full range of controller
- (o) Science:
 - (i) gas laws
 - (ii) vapour pressure
 - (iii) force, moments
 - (iv) elasticity, spring rates
 - (v) basic control theory
 - (vi) lubricants and their uses

. CONTROL .

BLOCK 25: Pneumatic Controllers

UNIT 3: Beam Type Force Balance
Controllers

OPERATIONS	KNOWLEDGE
1. Installing beam type force balance controllers	<ul style="list-style-type: none"> (a) Interpretation of drawings and piping diagrams to determine: <ul style="list-style-type: none"> (i) installation requirements (ii) location (iii) method of mounting and connecting (b) Principle of operation of controller and modes of control (c) Methods of mounting controller and installing, connecting, piping and tubing (d) Effects of vibration and methods of protection (e) Methods of protection against atmospheric corrosion (f) Procedures for checking for leaks (g) Procedures for putting controller into operation and checking for faults (h) Mathematics - <ul style="list-style-type: none"> linear measurement and Pythagoras' Theorem for layout and installation of tubing (i) Science: <ul style="list-style-type: none"> (i) gas laws (ii) atmospheric corrosion (iii) basic control theory (iv) vibration

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. CONTROL .

BLOCK 25: Pneumatic Controllers

UNIT 3: Beam Type Force Balance
Controllers

OPERATIONS

KNOWLEDGE

2. Calibrating and aligning beam
type force balance controllers

- (a) Interpretation of manufacturer's instruction manuals to determine calibration and alignment procedures
- (b) Methods of aligning controller using:
 - (i) calibrated receiver and set point transmitter
 - (ii) manifold and test manometers or gauges
- (c) Methods of mounting and connecting controller and test equipment
- (d) Procedures for testing for leaks
- (e) Methods of setting reset and rate time constants to minimum values
- (f) Methods of adjusting proportional band
- (g) Methods of preventing "pumping"
- (h) Procedures for aligning receiver pen and set point index, or adjusting controller output air pressure to midrange
- (i) Importance of repeating alignment tests at low and high values of proportional band
- (j) Methods of checking reset and rate systems for leaks or plugs
- (k) Procedures for checking reset and rate time values using test equipment
- (l) Mathematics:
 - (i) percentages, for calculating controller settings
 - (ii) ratio and proportion, for controller adjustment
 - (iii) conversion of pressure units
 - (iv) calculation of rates of pressure change
- (m) Science:
 - (i) laws of equilibrium, moments
 - (ii) linkages, levers
 - (iii) gas laws
 - (iv) flow through pipes
 - (v) basic control theory

. CONTROL .

BLOCK 25: Pneumatic Controllers

UNIT 3: Beam Type Force Balance
Controllers

OPERATIONS	KNOWLEDGE
3. Repairing and servicing beam type force balance controllers	<ul style="list-style-type: none"> (a) Interpretation of manufacturer's instruction manuals to determine repair and service procedure (b) Importance of providing a clean, dry air supply (c) Procedures for checking and servicing the air supply system and methods of measuring dew point (d) Methods of checking for air leaks or blockages (e) Methods of disconnecting or removing controller without disturbing the process (f) Importance of avoiding damage to gaskets when removing controller (g) Methods of replacing bellows and spring assemblies (h) Procedures for removing, repairing and replacing reset and rate assemblies (i) Methods of cleaning reducing tubes and orifices (j) Procedures for dismantling, repair and assembly of control relays (k) Importance of lubricating "O" rings, with correct type and amount of lubricant (l) Procedures for assembling controller and checking for correct operation (m) Science: <ul style="list-style-type: none"> (i) force, turning moments (ii) friction (iii) elasticity, spring rates (iv) linkages, levers (v) basic control theory (vi) vapour pressure (vii) lubricants and their uses

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. CONTROL .

BLOCK 25: Pneumatic Controllers

UNIT 4: Manual-Automatic Transfer Stations

OPERATIONS

KNOWLEDGE

- | | |
|---|---|
| 1. Installing manual-automatic selector stations | (a) Interpretation of drawings and manufacturer's instruction manuals to determine:
(i) method of mounting
(ii) dimensions of panel cut-outs
(iii) methods of connection
(b) Methods of mounting and connecting to associated control components
(c) Methods of connecting air supply, and checking for leaks
(d) Procedure for checking for correct operation
(e) Mathematics -
linear measurement for tubing layout
(f) Science -
gas laws |
| 2. Calibrating manual-automatic transfer stations | (a) Interpretation of manufacturer's instruction manuals to determine calibration procedures
(b) Methods of dismantling unit and removing pressure elements
(c) Type and characteristic of pressure elements:
(i) bourdon spring
(ii) bellows
(d) Methods of calibrating pressure elements, using test equipment
(e) Methods of assembly
(f) Procedures for checking for correct operation
(g) Mathematics -
conversion of pressure scales
(h) Science:
(i) Pascal's principle
(ii) elasticity, spring rates
(iii) linkages, gears |

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. CONTROL .

BLOCK 25: Pneumatic Controllers

UNIT 4: Manual-Automatic Transfer Stations

OPERATIONS

KNOWLEDGE

3. Repairing and servicing manual-automatic selector stations

- (a) Interpretation of manufacturer's instruction manuals to determine repair and service procedures
- (b) Importance of keeping air supply free of moisture, dirt and oil
- (c) Methods of checking dew-point of air supply
- (d) Procedure for removal and replacement of air drying media and filter elements
- (e) Procedure for checking for leaks in air lines
- (f) Importance of keeping vent holes open
- (g) Methods of checking signal from transmitter
- (h) Methods of removal, cleaning and replacement of pilot valves
- (i) Procedure for dismantling and assembling pilot valves
- (j) Methods of cleaning restriction orifice
- (k) Procedures for removal and examination of pneumatic switches and replacement of "O" rings
- (l) Methods of cleaning and lubrication of "O" rings
- (m) Methods of checking and adjusting linkages
- (n) Procedures for assembly, and checking for correct operation
- (o) Mathematics:
 - (i) conversion of pressure units
 - (ii) calculation of rates of pressure changes
- (p) Science:
 - (i) gas laws
 - (ii) vapour pressure
 - (iii) elasticity
 - (iv) linkages, levers
 - (v) lubricants and their uses

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. CONTROL .

BLOCK 25: Pneumatic Controllers

UNIT 5: Relays and Computers

OPERATIONS	KNOWLEDGE
<hr/>	
1. Installing pneumatic relays	<ul style="list-style-type: none">(a) Interpretation of drawings and instruction manuals to determine:<ul style="list-style-type: none">(i) installation requirements(ii) location(iii) method of mounting and connection(b) Type, principle of operation and functions of pneumatic relays(c) Importance of providing a clean dry air supply(d) Methods of mounting and connecting to associated equipment(e) Procedures for checking for leaks(f) Procedures for checking for correct operation(g) Mathematics -<ul style="list-style-type: none">linear measurement and Pythagoras' Theorem for piping layout(h) Science:<ul style="list-style-type: none">(i) vapour pressure of water(ii) gas laws

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. CONTROL .

BLOCK 25: Pneumatic Controllers

UNIT 5: Relays and Computers

OPERATIONS

KNOWLEDGE

2. Repairing and servicing
pneumatic relays

- (a) Interpretation of manufacturer's instruction manuals to determine repair and service procedures
- (b) Function of relay and principle of operation:
 - (i) manual loading
 - (ii) switching
 - (iii) reversing
 - (iv) amplifying or reducing
 - (v) limiting
 - (vi) delay
- (c) Use of test equipment and methods of connection
- (d) Methods of checking for leaks
- (e) Procedures for dismantling and cleaning components
- (f) Type and use of solvents
- (g) Type of gaskets
- (h) Methods of adjusting bias spring tension
- (i) Methods of replacement or repair of pilot valves and seats
- (j) Methods of cleaning orifices, nozzles, needle valves and air passages
- (k) Methods of assembly and importance of correct alignment of parts
- (l) Procedures for using test equipment for final checking and adjustment
- (m) Mathematics:
 - (i) conversion of pressure units
 - (ii) calculation of rates of pressure change
- (n) Science:
 - (i) gas laws
 - (ii) force, moments, balance
 - (iii) elasticity, spring rate
 - (iv) lubricants and their uses

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. CONTROL .

BLOCK 25: Pneumatic Controllers

UNIT 5: Relays and Computers

OPERATIONS

KNOWLEDGE

3. Installing pneumatic analog computers

- (a) Interpretation of drawings and piping diagrams to determine:
 - (i) installation requirements
 - (ii) location
 - (iii) method of mounting
- (b) Interpretation of manufacturer's instruction manuals to determine installation procedures
- (c) Type, characteristic and function of pneumatic analog computers
- (d) Methods of connection to obtain designed mathematical operation:
 - (i) summation
 - (ii) multiplication
 - (iii) division
 - (iv) function generation
 - (v) integration (reset action)
 - (vi) differentiation (rate action)
- (e) Importance of providing a clean dry air supply
- (f) Methods of mounting and connecting to associated transmitting and receiving instruments
- (g) Methods of checking for leaks
- (h) Procedure for checking for correct operation
- (j) Mathematics -
 - linear measurement and Pythagoras' Theorem for mounting and piping layout

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. CONTROL .

BLOCK 25: Pneumatic Controllers

UNIT 5: Relays and Computers

OPERATIONS	KNOWLEDGE
<hr/>	
4. Repairing and servicing pneumatic analog computers	<ul style="list-style-type: none">(a) Interpretation of manufacturer's instruction manuals to determine repair and service procedures(b) Use of test equipment and methods of connection(c) Methods of checking for leaks(d) Procedures for dismantling and cleaning components(e) Type and use of solvents(f) Type of gaskets and "O" rings and methods of replacement and lubrication(g) Methods of repair or replacement of pilot valves and seats(h) Methods of cleaning orifices, nozzles, needle valves and air passages(i) Procedures for assembly and importance of correct alignment of parts(j) Methods of adjusting bias spring tension(k) Methods of adjusting fulcrum and lever mechanisms(l) Procedures for using test equipment for final checking and adjustment(m) Science:<ul style="list-style-type: none">(i) gas laws(ii) laws of equilibrium(iii) principle of turning moments(iv) linkages, levers and mechanical advantages(v) elasticity and spring rates

BLOCK 26: Electric Controllers

TABLE OF CONTENTS

UNIT 1: On-Off Type Controllers	Page 510
2: Proportional Type Controllers	513
3: Computers	515

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. CONTROL .

BLOCK 26: Electric Controllers

UNIT 1: On-Off Type Controllers

OPERATIONS	KNOWLEDGE
<hr/>	
1. Installing on-off type electric controllers	<ul style="list-style-type: none">(a) Interpretation of drawings and wiring diagrams to determine:<ul style="list-style-type: none">(i) installation requirements(ii) location(iii) method of mounting and connecting(b) Interpretation of manufacturer's instruction manuals to determine installation procedures(c) Type and characteristic of measuring systems:<ul style="list-style-type: none">(i) bi-metallic strip(ii) pressure actuated devices(iii) millivoltmeters(iv) self-balancing bridges and potentiometers(d) Methods of actuating control circuits:<ul style="list-style-type: none">(i) mechanical(ii) photoelectric(iii) oscillator coil(iv) others(e) Type and characteristic of control action:<ul style="list-style-type: none">(i) multi-position(ii) duration adjusting(iii) floating(f) Type and characteristic of amplifier and relays and methods of connecting(g) Methods of mounting controllers(h) Effects of vibration and methods of protection(i) Effects of atmospheric conditions, methods of protection of electrical components and contacts against moisture, dust and corrosion(j) Methods of installing electrical wiring(k) Importance of adherence to relevant electrical codes and regulations(l) Methods of electromagnetic shielding(m) Procedure for setting control points and adjusting dead band

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. CONTROL .

BLOCK 26: Electric Controllers

UNIT 1: On-Off Type Controllers

OPERATIONS	KNOWLEDGE
<hr/>	
1. Installing on-off type electric controllers (cont'd)	<ul style="list-style-type: none">(n) Methods of connection to final control elements, such as:<ul style="list-style-type: none">(i) switches, relays(ii) heating elements(iii) electro-pneumatic relays(iv) electric motors(o) Procedure for checking system for correct operation(p) Mathematics -<ul style="list-style-type: none">linear measurement and Pythagoras' Theorem for wiring layout(q) Science:<ul style="list-style-type: none">(i) atmospheric corrosion(ii) thermal expansion(iii) temperature indicators and scales(iv) conductors and insulators(v) theory of electron flow(vi) elementary circuitry(vii) Ohm's law(viii) electromagnetism(ix) basic control theory

. CONTROL .

BLOCK 26: Electric Controllers

UNIT 1: On-Off Type Controllers

OPERATIONS	KNOWLEDGE
2. Repairing and servicing on-off type electric controllers	<ul style="list-style-type: none"> (a) Interpretation of manufacturer's instruction manuals to determine repair and service procedures (b) Purpose of control system and service conditions (c) Importance of not upsetting process and methods of operating process manually (d) Procedure and regulations for isolating and locking out electrical circuits from power supply (e) Methods of inspection and cleaning of electrical contacts (f) Methods of cleaning and lubricating slidewires (g) Procedures for inspection, cleaning and adjusting mechanical parts (h) Methods of checking continuity of electrical circuits and use of test equipment (i) Methods of checking vacuum tubes, transistors and other electronic components (j) Methods of checking, and repair or replacement of relays and transformers (k) Procedures for adjusting optical systems, and methods of replacement of light sources and photoelectric cells (l) Methods of making soldered connections (m) Procedures for putting control system into operation and checking for faults (n) Science: <ul style="list-style-type: none"> (i) theory of electron flow (ii) elementary circuitry (iii) Ohm's law (iv) electromagnetism (v) rectification (vi) oscillation (vii) nature of light, sources and transmission (viii) simple optics (ix) phot-electricity (x) basic control theory

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. CONTROL .

BLOCK 26: Electric Controllers

UNIT 2: Proportional Type Controllers

OPERATIONS

KNOWLEDGE

1. Installing proportional
type electric controllers

- (a) Interpretation of drawings, instruction manuals and wiring diagrams to determine:
 - (i) installation requirements
 - (ii) location
 - (iii) Method of mounting and connecting
- (b) Type and characteristic of control circuits:
 - (i) position adjusting (slidewire)
 - (ii) current adjusting (electronic)
- (c) Modes of control:
 - (i) proportional
 - (ii) proportional plus reset
 - (iii) proportional plus reset plus rate
- (d) Methods of mounting and fastening components
- (e) Effects of vibration and methods of protection
- (f) Effects of atmospheric conditions and methods of protection of components against moisture, dust and corrosion
- (g) Methods of installing electrical wiring
- (h) Importance of adherence to relevant electrical codes and regulations
- (i) Effect of temperature and allowable temperature limits
- (j) Effect of electromagnetic fields and methods of shielding
- (k) Effects of variations in line voltage, frequency and wave shape on controller operation and selection of voltage regulators
- (l) Methods and importance of correct grounding
- (m) Methods of connecting controller to final control element to obtain:
 - (i) direct action
 - (ii) reverse action
- (n) Methods of providing "fail-safe" operation of final control element in case of power failure
- (o) Procedures for putting control system into operation, and checking for faults

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. CONTROL .

BLOCK 26: Electric Controllers

UNIT 2: Proportional Type Controllers

OPERATIONS	KNOWLEDGE
<hr/>	
1. Installing proportional type electric controllers (cont'd)	(p) Mathematics: (i) linear measurement (ii) Pythagoras' Theorem (q) Science: (i) atmospheric corrosion (ii) heat transfer (iii) humidity (iv) conductors and insulators (v) theory of electron flow (vi) Ohm's law (vii) basic D.C. and A.C. electricity (viii) electronic circuits (ix) basic control theory

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. CONTROL .

BLOCK 26: Electric Controllers

UNIT 2: Proportional Type Controllers

OPERATIONS

KNOWLEDGE

2. Repairing and servicing proportional type electric controllers

- (a) Interpretation of manufacturer's instruction manuals and wiring diagrams to determine repair and service procedures
- (b) Purpose of control system and service conditions
- (c) Importance of not upsetting process, procedures for transferring process to manual control
- (d) Procedures and local regulations for isolating and locking-out electrical circuits from power supply
- (e) Methods of removing and replacing components
- (f) Methods of checking and replacement of vacuum tubes, transistors and electrolytic capacitors
- (g) Procedures for locating faults in power supply, converters and amplifiers
- (h) Methods of measuring and adjusting closure time of converter contacts and use of voltohmmeter and oscilloscope
- (i) Importance of sealing converter after adjustment
- (j) Methods of making voltage and resistance measurements
- (k) Procedures for checking and adjusting electronic or magnetic amplifiers
- (l) Procedures for removal and repair or replacement of servo-motors and associated mechanical components
- (m) Methods of making soldered connections and importance of using a non-corrosive flux
- (n) Temperature limitations of semi-conductors and importance of not over-heating when making soldered connection
- (o) Methods of cleaning and lubricating slidewires
- (p) Procedures for checking and adjusting manual-automatic selector units
- (q) Procedures for checking for correct operation
- (t) Mathematics -
 - calculation of voltage and resistance

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. CONTROL .

BLOCK 26: Electric Controllers

UNIT 2: Proportional Type Controllers

OPERATIONS

KNOWLEDGE

2. Repairing and servicing
proportional type electric
controllers (cont'd)

(u) Science:

- (i) theory of electron flow
- (ii) conductors and insulators
- (iii) Ohm's law
- (iv) electromagnetism
- (v) rectification and conversion
- (vi) A.C. and D.C. electricity
- (vii) theory of electronic and
magnetic amplification
- (viii) electrostatics
- (ix) two-phase electric motors
- (x) cathode ray tubes
- (xi) solid state electronic devices
- (xii) basic control theory

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. CONTROL .

BLOCK 26: Electric Controllers

UNIT 3: Computers

OPERATIONS

KNOWLEDGE

1. Installing electric analog computers

- (a) Interpretation of drawings, instruction manuals and wiring diagrams to determine:
 - (i) installation requirements
 - (ii) location
 - (iii) method of mounting
- (b) Type, principle of operation and functions of electric analog computers
- (c) Methods of connecting and wiring components to obtain desired mathematical operation:
 - (i) summation
 - (ii) multiplication
 - (iii) division
 - (iv) function generation
 - (v) integration (reset action)
 - (vi) differentiation (rate action)
- (d) Methods of mounting and fastening components
- (e) Effects of vibration and methods of protection
- (f) Effects of atmospheric conditions and methods of protection against dust, moisture and corrosion
- (g) Methods of installing electrical wiring
- (h) Importance of adherence to relevant electrical codes and regulations
- (i) Effects of ambient temperature on components and allowable temperature limits
- (j) Effect of electromagnetic fields and methods of shielding
- (k) Effects of variations in line voltage, frequency and wave shape on computer operation, selection of voltage regulators
- (l) Method and importance of correct grounding components
- (m) Procedures for putting computer into operation and checking for faults
- (n) Mathematics -
 - linear measurement and Pythagoras' Theorem for wiring layout

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. CONTROL .

BLOCK 26: Electric Controllers

UNIT 3: Computers

OPERATIONS

KNOWLEDGE

2. Repairing and servicing
electric analog computers

- (a) Interpretation of manufacturer's instruction manuals and wiring diagrams to determine repair and service procedures
- (b) Methods of removing and replacing components
- (c) Methods of checking and replacement of vacuum tubes, transistors and electrolytic capacitors
- (d) Procedures for locating faults in power supplies, converters and amplifiers
- (e) Methods of making voltage and resistance measurements
- (f) Methods of measuring and adjusting closure time of converter contacts
- (g) Methods of cleaning and lubricating slidewire
- (h) Procedure for checking and adjusting electronic and magnetic amplifiers
- (i) Procedures for removal and repair or replacement of servo-motors and associated mechanical components
- (j) Methods of making soldered connections and importance of using a non-corrosive flux
- (k) Temperature limitations of semi-conductors and importance of not over-heating when making soldered connections
- (l) Procedures for checking for correct operation
- (m) Mathematics -
 - calculation of voltage and resistance
- (n) Science:
 - (i) theory of electron flow
 - (ii) Ohm's law
 - (iii) electromagnetism
 - (iv) rectification and conversion
 - (v) AC and DC electricity
 - (vi) electronic and magnetic amplification
 - (vii) electrostatics
 - (viii) two-phase electric motors
 - (ix) cathode ray tubes
 - (x) solid state electronic devices

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. CONTROL .

BLOCK 27: Control Systems

TABLE OF CONTENTS

UNIT 1: Single Loop Control	Page 520
2: Multi-Loop Control	522
3: Cascade Control	523
4: Ratio Control	525
5: Time Function Control	528

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. CONTROL .

BLOCK 27: Control Systems

UNIT 1: Single Loop Control

OPERATIONS	KNOWLEDGE
<hr/>	
1. Adjusting single loop control systems	<ul style="list-style-type: none">(a) Process characteristics and requirements:<ul style="list-style-type: none">(i) variable being controlled(ii) range of control settings and allowable deviations from set point(iii) process capacitances and lags(iv) effects of failure of control system(b) Control characteristics of measuring system:<ul style="list-style-type: none">(i) measurement lags(ii) transmission lags(c) Type of control action and their characteristics:<ul style="list-style-type: none">(i) on-off or multi-position(ii) floating(iii) duration adjusting(iv) proportional(v) proportional plus reset(vi) proportional plus reset plus rate(d) Type and characteristic of control devices:<ul style="list-style-type: none">(i) self-operated(ii) hydraulic(iii) pneumatic(iv) electric(e) Effects of capacitances and lags on controllability of process(f) Importance of not upsetting process during adjustment of controller(g) Methods of transferring process to manual control(h) Importance of "dead band" in on-off or floating control, and methods of adjustment(i) Effect of floating speed on stability of floating type controllers and methods of adjustment(j) Effects of pulse time on control characteristics of duration adjusting type controllers, and methods of adjustment

AN ANALYSIS OF THE INDUSTRIAL INSTRUMENTATION TRADE

. CONTROL .

BLOCK 27: Control Systems

UNIT 1: Single Loop Control

OPERATIONS	KNOWLEDGE
<hr/>	
1. Adjusting single loop control systems (cont'd)	<ul style="list-style-type: none">(k) Methods of calculating optimum proportional band, reset time, and rate time by:<ul style="list-style-type: none">(i) systematic trial methods(ii) ultimate sensitivity method(iii) reaction curve method(l) Effects of non-linearities in the control loop on stability, importance of making adjustments under the most unstable conditions(m) Importance of allowing sufficient time after making an adjustment to observe the full effect(n) Procedures for checking for correct operation of all components(o) Mathematics:<ul style="list-style-type: none">(i) calculation of process reaction rates and controller settings(ii) powers and roots(iii) graphs, plotting and reading(iv) substitution of numerical values in algebraic terms(v) sine curves, frequency, amplitude, phase(vi) logarithms, use of slide rule(p) Science:<ul style="list-style-type: none">(i) units of measurement (flow, pressure, temperature)(ii) heat transfer(iii) flow through pipes(iv) theory of electron flow(v) basic A.C. and D.C. electricity(vi) basic control theory

. CONTROL .

BLOCK 27: Control Systems

UNIT 2: Multi-Loop Control

OPERATIONS

KNOWLEDGE

-
- | | |
|--|--|
| 1. Adjusting two or three element control systems (e.g. boiler drum level control) | (a) Type and characteristic of measuring systems for: <ul style="list-style-type: none"> (i) water flow (ii) steam flow (iii) boiler drum level (b) Type and characteristic of signal transmission systems: <ul style="list-style-type: none"> (i) pneumatic (ii) electric (c) Control valve types and characteristic (d) Procedures for checking linearity of feed water control valve (e) Methods of adjusting feed water valve positioner to obtain linear relation between in put signal and water flow (f) Methods of determining steam and water flow meter output signals at: <ul style="list-style-type: none"> (i) 100% flow (ii) 50% flow (iii) 10% flow (g) Methods of adjusting steam flow - water flow ratio controller (h) Methods of adjusting proportional band of level controller to give desired percentage change of water flow per inch change of drum level (i) Procedures for checking for correct operation of all components (j) Mathematics: <ul style="list-style-type: none"> (i) calculation of pneumatic and electrical signal values (ii) ratio and proportion (iii) powers and roots (iv) percentage (v) substitution of numerical values in algebraic terms (k) Science: <ul style="list-style-type: none"> (i) vapour pressure of liquids (ii) gas laws (iii) heat energy and transfer (iv) flow through pipes (v) basic A.C. and D.C. electricity (vi) theory of electron flow (vii) basic control theory |
|--|--|
-

. CONTROL .

BLOCK 27: Control Systems

UNIT 3: Cascade Control

OPERATIONSKNOWLEDGE

1. Adjusting cascade control systems

- (a) Purpose of control system
- (b) Process characteristics affecting control and process requirements:
 - (i) capacitances and lags
 - (ii) range of control settings and allowable deviation from set point
 - (iii) effects of failure of control systems
- (c) Characteristics of measuring systems affecting control:
 - (i) measurement lags
 - (ii) transmission lags
- (d) Importance of not upsetting process - permissible deviations from set point during controller adjustment
- (e) Methods of isolating primary and secondary control circuits
- (f) Methods of operating process by manual control
- (g) Procedures for calculating and adjusting optimum proportional band, reset time and rate time of secondary (slave) controller
- (h) Methods of connecting primary (master) controller to set point of slave controller
- (i) Procedures for calculating and adjusting optimum proportional band, reset time and rate time of master controller
- (j) Importance of allowing sufficient time after making an adjustment to observe full effect
- (k) Procedures for checking for correct operation of all components

. CONTROL .

BLOCK 27: Control Systems

UNIT 3: Cascade Control

OPERATIONS	KNOWLEDGE
1. Adjusting cascade control systems (cont'd)	<ul style="list-style-type: none">(l) Mathematics:<ul style="list-style-type: none">(i) calculation of process reaction rates and controller settings(ii) powers and roots(iii) ratio and proportion(iv) percentage(v) graphs, plotting and reading(vi) substitution of numerical values in algebraic terms(vii) sine curves, frequency, amplitude, phase(viii) logarithms, use of slide rule(m) Science:<ul style="list-style-type: none">(i) units of measurement (flow pressure, temperature, etc.)(ii) heat transfer(iii) flow through pipes(iv) gas laws(v) basic A.C. and D.C. electricity(vi) theory of electron flow(vii) basic control theory

. CONTROL .

BLOCK 27: Control Systems

UNIT 4: Ratio Control

OPERATIONS	KNOWLEDGE
1. Adjusting ratio control systems	<ul style="list-style-type: none"> (a) Purpose of control system (b) Process variables being controlled, and methods of measurement (c) Type and characteristic of signal transmission systems: <ul style="list-style-type: none"> (i) mechanical (ii) pneumatic (iii) electric (d) Minimum, maximum and normal values of primary variable (e) Desired ratios of primary to secondary variables (f) Methods of controlling secondary variables by: <ul style="list-style-type: none"> (i) closed loop controllers (ii) controlled volume pumps (iii) feeders, weighers (g) Type and characteristic of ratio control mechanisms: <ul style="list-style-type: none"> (i) mechanical (ii) pneumatic (iii) electric (iv) hydraulic (h) Procedures for calculating and adjusting optimum proportional band, reset time, and rate time of secondary variable controller (i) Type of electric motor speed controls and variable speed drives, and methods of adjusting speed and range (j) Methods of adjusting stroke and speed of controlled volume pumps (k) Methods of setting desired ratios (l) Procedures for putting control system into operation and checking for faults (m) Mathematics: <ul style="list-style-type: none"> (i) conversion of volume and weight units of measurement (ii) calculation of controller settings (iii) powers and roots (iv) ratio and proportion (v) percentages

. CONTROL .

BLOCK 27: Control Systems

UNIT 4: Ratio Control

OPERATIONS	KNOWLEDGE
1. Adjusting ratio control systems (cont'd)	(n) Science: (i) levers, linkages (ii) flow-through pipes (iii) gas laws (iv) Pascal's principle (v) basic A.C. and D.C. electricity (vi) basic control theory

. CONTROL .

BLOCK 27: Control Systems

UNIT 4: Ratio Control

OPERATIONS	KNOWLEDGE
2. Adjusting steam boiler combustion control systems	<p>(a) Preliminary procedures required to ensure:</p> <ul style="list-style-type: none"> (i) correct draft connections (ii) correct operation of boiler outlet damper, feed water regulator and furnace draft controller (iii) proper condition of baffles and boiler walls (iv) constant feed water temperature (v) constant steam pressure (vi) suitability of plant operating conditions for controller adjustment <p>(b) Procedures for adjusting fuel and air flows at 30% boiler capacity</p> <p>(c) Methods of analysing boiler outlet gases for CO₂, CO and oxygen, use of orsat apparatus</p> <p>(d) Interpretation of combustion air curves for:</p> <ul style="list-style-type: none"> (i) coal (ii) oil (iii) natural gas (iv) other fuels <p>(e) Procedures for calculating correct steam flow-air flow or fuel flow - air flow ratios and methods of adjustment</p> <p>(f) Procedures for repeating above adjustments at 60% and 80% of boiler capacity</p> <p>(g) Procedures for making final ratio adjustments</p> <p>(h) Mathematics:</p> <ul style="list-style-type: none"> (i) percentage (ii) powers and roots (iii) ratio and proportion (iv) conversion of volume units (v) graphs, plotting and reading <p>(i) Science:</p> <ul style="list-style-type: none"> (i) combustion and fuels (ii) composition of air (iii) gas analysis for CO₂, CO and O₂

. CONTROL .

BLOCK 27: Control Systems

UNIT 5: Time Function Control

OPERATIONS	KNOWLEDGE
1. Adjusting time function control systems	<ul style="list-style-type: none"> (a) Purpose of control system (b) Process characteristics affecting control (c) Type of time function control required: <ul style="list-style-type: none"> (i) on-off (time switch) (ii) time delay (iii) time interval (iv) time cycle (v) time schedule (d) Type and characteristic of time measuring devices and methods of regulating: <ul style="list-style-type: none"> (i) mechanical (ii) electric (e) Methods of controlling time intervals: <ul style="list-style-type: none"> (i) mechanical or electric motor driven mechanisms (ii) crystal oscillator (iii) capacitor charge or discharge (iv) flux decay (v) thermal (vi) dashpot (vii) pneumatic (viii) inertia (f) Type and characteristic of time delay, relays, and methods of adjustment (g) Methods of setting time intervals (h) Methods of laying out, cutting and fitting metal or plastic cams (i) Methods of adjusting electrical contacts and switches (j) Mathematics: <ul style="list-style-type: none"> (i) percentages, for calculating time intervals (ii) graphs, drawings and reading (iii) geometry of a circle (iv) calculation of cam profiles (k) Science: <ul style="list-style-type: none"> (i) thermal expansion (ii) electro-magnetism (iii) basic A.C. and D.C. electricity (iv) cams, levers, linkages (v) theory of electron flow (vi) basic control theory

BLOCK 28: Final Control Elements

TABLE OF CONTENTS

UNIT 1: Positioners	Page 530
2: Operators	533
3: Valves	539
4: Servo-Motors	543

. CONTROL .

BLOCK 28: Final Control Elements UNIT 1: Positioners

OPERATIONS	KNOWLEDGE
1. Installing positioners	<ul style="list-style-type: none"> (a) Interpretation of manufacturer's literature to determine: <ul style="list-style-type: none"> (i) principles of operation (ii) mounting details (iii) connecting details (b) Type, purpose and characteristic of positioners: <ul style="list-style-type: none"> (i) pneumatic position balance and force balance (ii) pneumatic-hydraulic (iii) electro-pneumatic (iv) electro-hydraulic (c) Type, purpose and method of using characterized cams with positioners (d) Type of long stroke positioners (e) Purpose and methods of split-ranging positioners (f) Methods of obtaining reverse or direct action (g) Methods of mounting positioners: <ul style="list-style-type: none"> (i) external (ii) internal (h) Methods of connecting positioners to valve stems (i) Methods of mounting or installing: <ul style="list-style-type: none"> (i) plastic or metal tubing connections (ii) small air or water regulators and filter stations (iii) electrical connections (iv) piping connections (j) Type and use of screw fasteners and locking devices (k) Methods of testing positioners after installation (l) Mathematics: <ul style="list-style-type: none"> (i) linear and angular dimensions to determine correct linkage relations (ii) plotting simple graphs to determine cam characteristics (m) Science: <ul style="list-style-type: none"> (i) linkages, levers, cams (ii) mechanical advantage of simple machines (iii) elementary circuitry

. CONTROL .

BLOCK 28: Final Control Elements UNIT 1: Positioners

OPERATIONS

KNOWLEDGE

2. Calibrating positioners

- (a) Interpretation of manufacturer's literature to determine:
 - (i) principles of operation
 - (ii) methods of adjusting
 - (iii) input - output ranges
 - (iv) valve application
 - (v) service conditions
 - (vi) connection details
- (b) Type and use of shop and field pneumatics, hydraulic and electrical test equipment
- (c) Use of precision linear measuring devices
- (d) Methods of adjusting springs in tension or compression or changing spring rate
- (e) Procedures for calibrating pilot valves or relays
- (f) Methods for determining or shaping characterized cams
- (g) Methods of adjusting maximum and minimum limit stops
- (h) Procedures for checking and adjusting:
 - (i) zero
 - (ii) span
 - (iii) linearity
 - (iv) input - output characteristics
- (i) Methods of adjusting for split ranges
- (j) Importance of proper alignment of nozzle-baffle or pilot stem components
- (k) Mathematics:
 - (i) ratio and proportion and simple equations for determining input - output relations
 - (ii) linear and angular dimensions for adjusting linkages and levers
 - (iii) plotting graphs for determination of results and shaping cams
- (l) Science:
 - (i) basic electricity, pneumatics and hydraulics
 - (ii) linkages, levers and cams
 - (iii) mechanical advantage of simple machines

. CONTROL .

BLOCK 28: Final Control Elements UNIT 1: Positioners

OPERATIONS

KNOWLEDGE

3. Servicing positioners

- (a) Interpretation of manufacturer's literature to determine:
 - (i) recommended maintenance procedures
 - (ii) parts identification
 - (iii) assembly details
 - (iv) input - output values
- (b) Type, use, and method of repairing and replacing component parts of pilot valves and pilot relays
- (c) Methods of cleaning, aligning or replacing nozzle-baffle components
- (d) Procedures for dead-end testing of bellows
- (e) Importance of checking for worn or damaged linkages, bearings and pivots
- (f) Methods of replacing gaskets and seals
- (g) Type and use of screw fasteners and locking devices
- (h) Importance of checking for correct alignment of linkages, beams and pilot stems
- (i) Importance of checking for reverse or direct action
- (j) Methods of checking for electrical shorts or open circuits
- (k) Type, use and method of repairing or replacing gauges and by-pass valve assemblies
- (l) Type, use and replacement of pneumatic, hydraulic and electrical connections and fittings
- (m) Effects of corrosive atmospheres
- (n) Importance of testing and/or calibrating positioners after repairing
- (o) Mathematics:
 - (i) linear and angular dimensions for checking alignment
 - (ii) ratio and proportion and simple equations for determining input - output relations
- (p) Science:
 - (i) linkages, levers and cams
 - (ii) mechanical advantage
 - (iii) basic pneumatics, hydraulics and electricity
 - (iv) atmospheric corrosion

. CONTROL .

BLOCK 20: Final Control Elements UNIT 2: Operators

OPERATIONS	KNOWLEDGE
1. Installing operators	<ul style="list-style-type: none"> (a) Interpretation of manufacturer's literature to determine: <ul style="list-style-type: none"> (i) type of operator (ii) method of attachment to valve body and valve stem (iii) correct action of operator (iv) length of stroke or angle of rotation (v) spring range (vi) pneumatic, hydraulic or electrical values (vii) direct or reverse action (viii) fail safe action (b) Type, size and construction of operators: <ul style="list-style-type: none"> (i) spring and diaphragm (ii) springless diaphragm (iii) cylinder (iv) bellows (v) air motor (vi) electric motor (vii) hydraulic motor (viii) combinations (c) Methods of mounting operators on valve bodies (d) Type, use and method of mounting operator components such as gear trains, rack and pinions, worm and wheels, chains and lever systems (e) Methods of joining operator stems to valve stems (f) Type, use, and correct mounting of travel indicators (g) Type, purpose and method of installing hand-jack accessories (h) Importance of correct alignment between operator and valve stems (i) Type and method of making signal and motive power connections to operators (j) Methods of testing operators (k) Use of test equipment (l) Use of anti-corrosive materials and finishes

. CONTROL .

BLOCK 28: Final Control Elements UNIT 2: Operators

OPERATIONS	KNOWLEDGE
1. Installing operators (cont'd)	<ul style="list-style-type: none">(m) Effects of horizontal vs. vertical mounting of operators and importance of supporting large operators(n) Type and use of screw fasteners and locking devices(o) Mathematics:<ul style="list-style-type: none">(i) linear and angular dimensions to determine correct assembly of levers, linkages, gears and stems(ii) ratio and proportion to determine stroke to signal relations(p) Science:<ul style="list-style-type: none">(i) levers, linkages, rack and pinion, gears and gear trains, worm and wheel, chains(ii) mechanical advantage of simple machines(iii) springs and spring forces(iv) basic pneumatics, hydraulics and electricity

. CONTROL .

BLOCK 28: Final Control Elements UNIT 2: Operators

OPERATIONS

KNOWLEDGE

2. Calibrating operators

- (a) Interpretation of manufacturer's literature to determine:
 - (i) type of operator
 - (ii) motive power and signal range
 - (iii) spring range
 - (iv) type of actuation
 - (v) direct or reverse acting
 - (vi) adjustment details
- (b) Type, use and adjustment of actuators
- (c) Methods of checking for maximum and minimum stroke
- (d) Methods of checking and adjusting stem position vs. motive power or signal value
- (e) Importance of determining and adjusting spring ranges
- (f) Procedures for checking and setting up gear trains, worms, levers and cams of actuators
- (g) Type, use and adjustment of stroke indicators
- (h) Methods used for providing direct or reverse action
- (i) Effects of fluid dynamics in valve body on operator calibration
- (j) Procedures used to check for hysteresis
- (k) Type and use of pneumatic, hydraulic, and electrical shop and field test equipment
- (l) Type of signal and motive power connections
- (m) Methods of adjusting electrical limit switches, stepping switches, rheostats etc.
- (n) Type, size and use of screw fasteners and locking devices
- (o) Type, size and use of bearings

. CONTROL .

BLOCK 28: Final Control Elements UNIT 2: Operators

OPERATIONSKNOWLEDGE

2. Calibrating operators (cont'd) (p) Mathematics:

- (i) linear and angular dimensions to determine stem and linkage positions
- (ii) ratio and proportion and simple equations to determine relations between signal or motive force values and stem positions
- (iii) plotting simple graphs and percentage to compare results against standards

(q) Science:

- (i) mechanical advantage
- (ii) spring forces, cams, levers, linkage
- (iii) gear trains, worm and wheel
- (iv) elementary **fluid dynamics**
- (v) elementary electrical theory
- (vi) basic pneumatics and hydraulics

. CONTROL .

BLOCK 28: Final Control Elements UNIT 2: Operators

OPERATIONS

KNOWLEDGE

3. Servicing operators

- (a) Interpretation of manufacturer's literature to determine:
 - (i) type and construction details
 - (ii) motive power and/or signal range
 - (iii) spring range
 - (iv) type and speed of actuation
 - (v) direct or reverse acting
 - (vi) adjustment details
 - (vii) disassembly and assembly details
 - (viii) recommended maintenance procedure
 - (ix) parts description and identification
- (b) Type, material and construction details of operators
- (c) Importance of visual inspection of exposed parts to determine worn, loose, or damaged components
- (d) Effects of corrosive atmospheres
- (e) Methods used to protect operators or their components against corrosive atmospheres
- (f) Methods of testing the response of operators for:
 - (i) correct speed
 - (ii) hysteresis
 - (iii) range
 - (iv) starting point
 - (v) correct action
- (g) Type and use of shop and field test equipment
- (h) Causes of hysteresis
- (i) Methods of repairing or replacing component parts:
 - (i) diaphragms
 - (ii) springs
 - (iii) pneumatic, hydraulic and pneumatic motors
 - (iv) linkages, stems and bearings
 - (v) power and signal connections
 - (vi) fasteners and locking devices
 - (vii) others
- (j) Importance of protective coatings and lubrication
- (k) Effects of line vibration

. CONTROL .

BLOCK 28: Final Control Elements UNIT 2: Operators

OPERATIONS	KNOWLEDGE
3. Servicing operators (cont'd)	<ul style="list-style-type: none"> (l) Procedures and components used for modifying the effect of fluid dynamics (m) Importance of properly supporting large operators (n) Methods of repairing or replacing electrical components (o) Mathematics: <ul style="list-style-type: none"> (i) linear and angular measurements to determine stroke relations (ii) ratio and proportion to determine signal to stroke relations (iii) simple equations to determine response to signals changes (p) Science: <ul style="list-style-type: none"> (i) corrosion (ii) lubricants and their uses (iii) linkages, levers and cams (iv) gears, worm and wheel rack and pinion (v) velocity and rate (vi) friction, torque, power (vii) synthetic rubber (viii) elementary, pneumatic, hydraulic and electrical theory

. CONTROL .

BLOCK 28: Final Control Elements UNIT 3: Valves

OPERATIONS

KNOWLEDGE

1. Installing valves

- (a) Interpretation of drawings to determine:
 - (i) location
 - (ii) line size
 - (iii) process fluid type, pressure and temperature
 - (iv) service connections
 - (v) support details
 - (vi) identification details
- (b) Interpretation of manufacturer's literature to determine:
 - (i) valve type and size
 - (ii) clearance requirements
 - (iii) recommended installation procedure
 - (iv) service conditions or rating
 - (v) direction of flow
 - (vi) material of construction
- (c) Type, purpose, use and construction details of valve bodies:
 - (i) globe
 - (ii) angle
 - (iii) gate
 - (iv) plug
 - (v) ball
 - (vi) butterfly or vane
 - (vii) others
- (d) Use of reversible bodies
- (e) Type, purpose use and construction details of valve bonnets and stuffing boxes
- (f) Type and method of selecting stem packings
- (g) Type and use and construction of seals and cooling sections
- (h) Use and construction of shaft purging assemblies
- (i) Methods of heating valve bodies
- (j) Methods of constructing inner valves or plugs
- (k) Characteristics of inner valves
- (l) Methods of sizing valves and selecting characteristic to suit the process
- (m) Advantages and disadvantages of:
 - (i) single port
 - (ii) double port

. CONTROL .

BLOCK 28: Final Control Elements UNIT 3: Valves

OPERATIONS	KNOWLEDGE
<hr/>	
1. Installing valves (cont'd)	(n) Effect and causes of: <ul style="list-style-type: none">(i) hysteresis(ii) unbalanced forces
	(o) Importance of valve sensitivity
	(p) Type of end connections: <ul style="list-style-type: none">(i) flanged(ii) screwed(iii) welded(iv) others
	(q) Importance of providing clearance for disassembly of valve components
	(r) Importance of correct alignment
	(s) Methods of supporting valve bodies
	(t) Type, use, and material of pipe gaskets and thread compounds
	(u) Type, use and size of screw fasteners and locking devices
	(v) Mathematics: <ul style="list-style-type: none">(i) linear and angular measurement to determine component size and alignment(ii) powers, roots, logarithms, per cent, graphs and simple equations to understand valve characteristics(iii) calculations of areas and volumes to determine pressures, forces and capacities
	(w) Science: <ul style="list-style-type: none">(i) Pascal's principle(ii) elementary fluid dynamics(iii) units of mass and force

. CONTROL .

BLOCK 28: Final Control Elements UNIT 3: Valves

OPERATIONS

KNOWLEDGE

2. Servicing valves

- (a) Interpretation of manufacturer's literature to determine:
 - (i) type and construction
 - (ii) assembly and disassembly methods
 - (iii) action
 - (iv) material
 - (v) parts description
 - (vi) service ratings
 - (vii) recommended maintenance procedure
- (b) Methods of removing and replacing valve actuators
- (c) Methods of disassembly and assembly of:
 - (i) packing
 - (ii) seals
 - (iii) cooling components
 - (iv) purging components
 - (v) bonnets
- (d) Procedures for removing or installing:
 - (i) valve cages
 - (ii) inner valves or plugs
 - (iii) guides
 - (iv) seats
- (e) Type, use and service condition of valve packings
- (f) Methods of attaching stems to inner
- (g) Methods of attaching vanes to valve shafts
- (h) Procedures for repairing seats and plugs:
 - (i) refacing
 - (ii) lapping
- (i) Importance of correct alignment and clearance of valve guides
- (j) Type and method of reversing the action of valves
- (k) Methods of protecting valve stems from corrosion
- (l) Methods of lubricating valve stems or shafts
- (m) Effects of unbalanced forces
- (n) Causes of hunting
- (o) Results of and methods for determining an incorrectly sized or out of range valve

. CONTROL .

BLOCK 28: Final Control Elements UNIT 3: Valves

OPERATIONS	KNOWLEDGE
2. Servicing valves (cont'd)	<p>(p) Importance of the valve location in the process pipe</p> <p>(q) Causes, effects and methods of reducing or eliminating vibration</p> <p>(r) Causes of body erosion or plugging</p> <p>(s) Effects of flashing liquids</p> <p>(t) Methods of removing or replacing broken studs</p> <p>(u) Type of screw fasteners and locking devices</p> <p>(v) Type, use and material of gaskets</p> <p>(w) Mathematics:</p> <p> (i) linear and angular measurement for determining component sizes, alignment and layout</p> <p> (ii) use of tables, graphs and equations to understand sizing of valves</p> <p>(x) Science:</p> <p> (i) vapors, gases, and liquids</p> <p> (ii) elementary fluid dynamics</p> <p> (iii) plastic materials</p> <p> (iv) corrosion</p> <p> (v) lubricants and their uses</p> <p> (vi) force and pressure</p> <p> (vii) heat and temperature</p> <p> (viii) expansion and contraction of metals</p>

. CONTROL .

BLOCK 28: Final Control Elements UNIT 4: Servo Motors

OPERATIONS	KNOWLEDGE
1. Installing and servicing servo motors	<ul style="list-style-type: none"> (a) Interpretation of drawings to determine: <ul style="list-style-type: none"> (i) purpose and function (ii) location (iii) mounting details (iv) service requirements and installation (b) Interpretation of manufacturer's literature to determine: <ul style="list-style-type: none"> (i) principle of operations (ii) rating (iii) recommended service requirements (iv) assembly and disassembly details (v) motive power and/or signal connections (vi) recommended maintenance procedure (vii) lubrication requirements (c) Type, purpose, construction and operating principle of servo-motors to produce linear or rotary motion: <ul style="list-style-type: none"> (i) pneumatic (ii) hydraulic (iii) electric (d) Type, use, function and method of installing regulating systems for motive fluid or electric power (e) Importance and methods of providing clean motive fluids (f) Effects of temperature and viscosity variations on hydraulic system components (g) Type and characteristic of hydraulic fluids (h) Procedures and components used for controlling servo-motors (i) Methods of maintaining and repairing fluid components such as: <ul style="list-style-type: none"> (i) pressure regulators (ii) relief valves (iii) pumps (iv) switches (v) spool and rotary valves (j) Methods of maintaining and repairing small electric motors

. CONTROL .

BLOCK 28: Final Control Elements UNIT 4: Servo-Motors

OPERATIONS	KNOWLEDGE
1. Installing and servicing servo motors (cont'd)	<ul style="list-style-type: none"> (k) Type, use, and method of installing or repairing: <ul style="list-style-type: none"> (i) couplings (ii) gears (iii) rack and pinions (iv) bearings (v) shaft keys (l) Importance of correct lubrication (m) Methods of checking or changing direction of rotation, speed and torque (n) Methods of making tubing, piping, or electrical connections (o) Use of devices, such as slidewires to provide remote indication of rotation or position (p) Procedures for disassembling and assembling pneumatic and hydraulic servo-motors (q) Methods of replacing or repairing component parts, seals and gaskets of servo-motors (r) Use of cleaning solvents (s) Importance of flushing hydraulic systems (t) Methods of removing air from hydraulic systems (u) Causes and methods of reducing hydraulic hammer (v) Mathematics: <ul style="list-style-type: none"> (i) linear and angular measurements for layout (ii) calculations to determine linear and angular speeds (iii) roots, powers, ratio and proportion to determine pressure, force and torque (w) Science: <ul style="list-style-type: none"> (i) basic pneumatics, hydraulics and electricity (ii) hydraulic fluids, solvents (iii) lubricants and their uses (iv) velocity and acceleration (v) torque (vi) piston motion (vii) levers, gears, racks and pinions

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